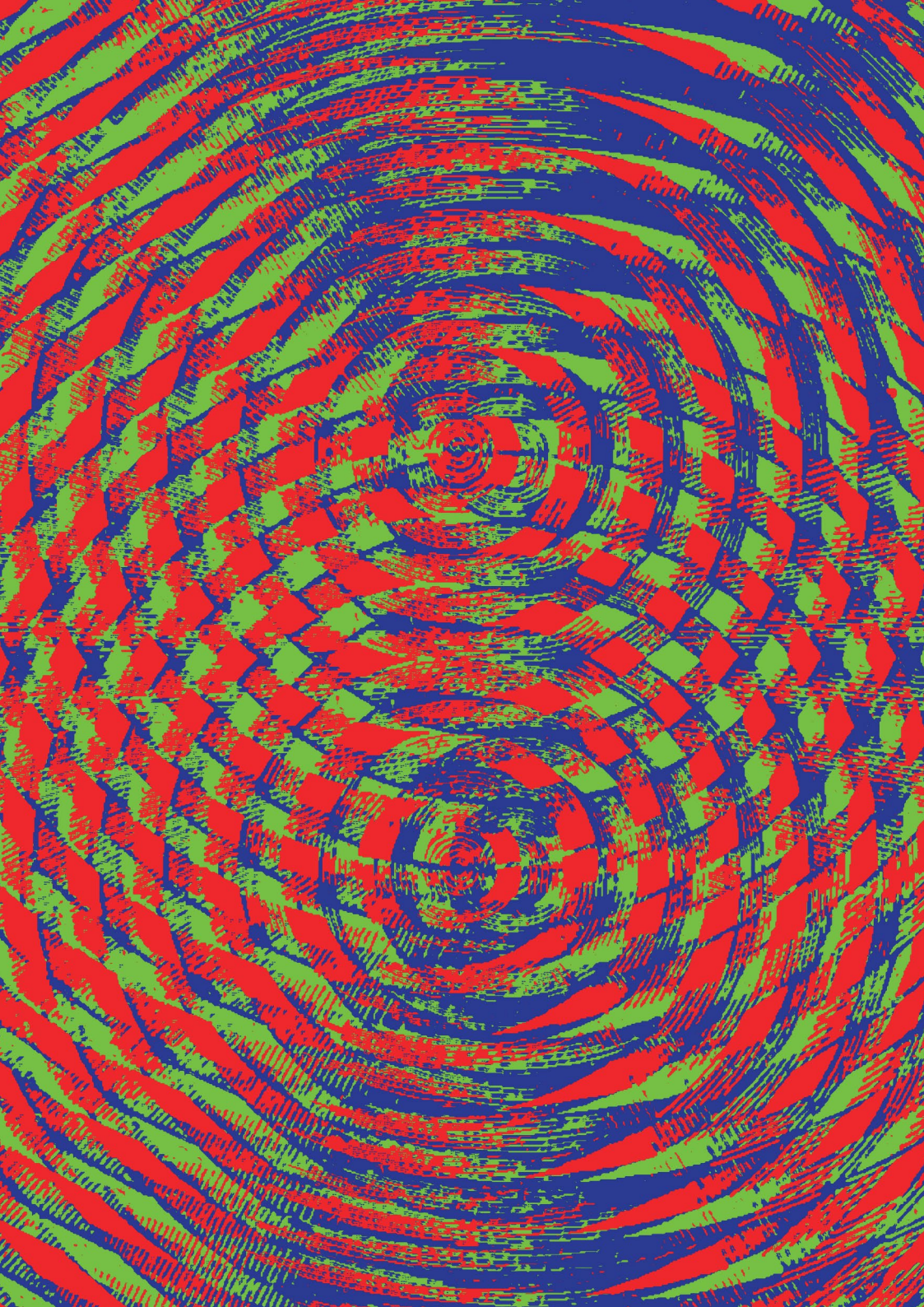

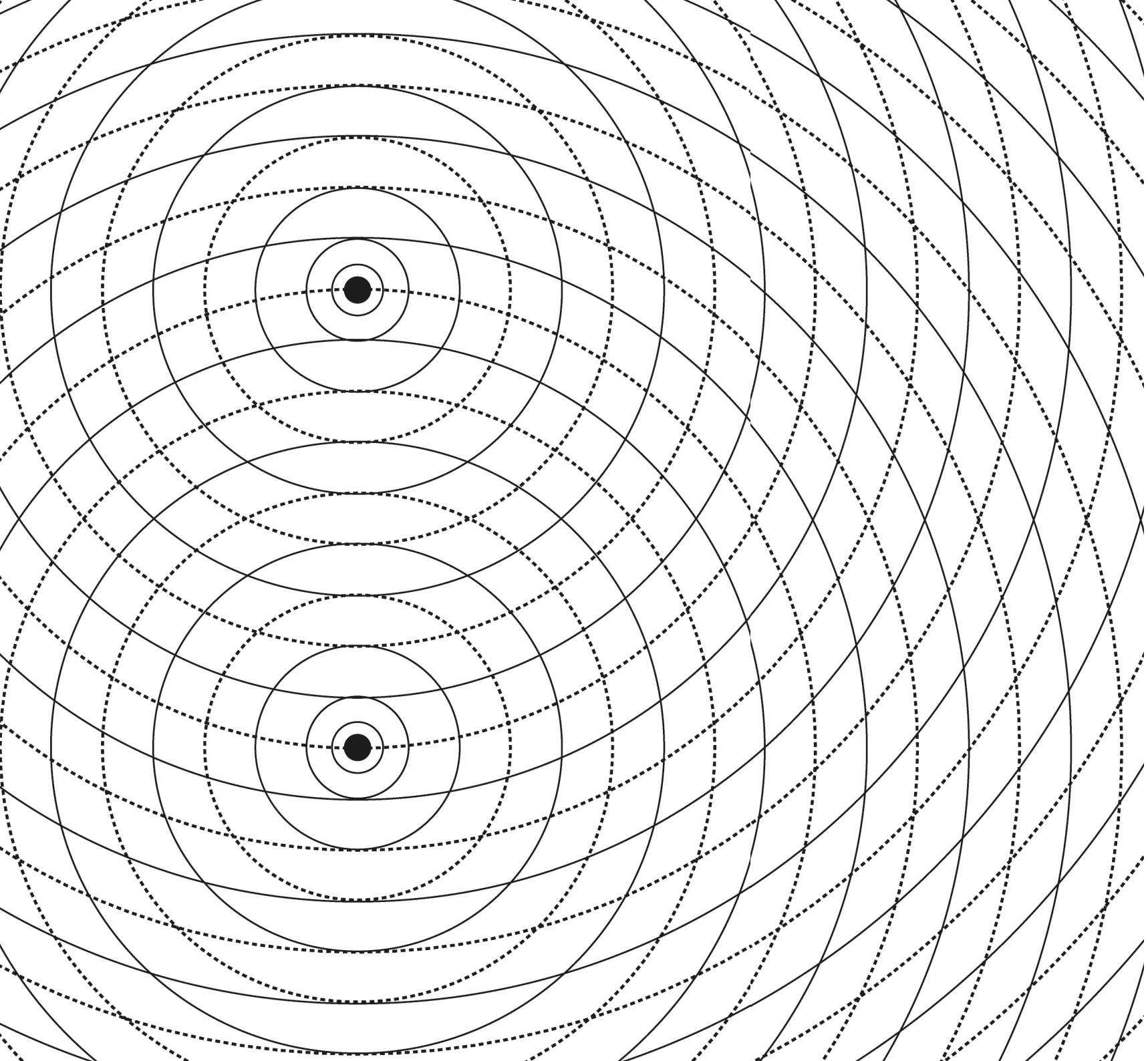

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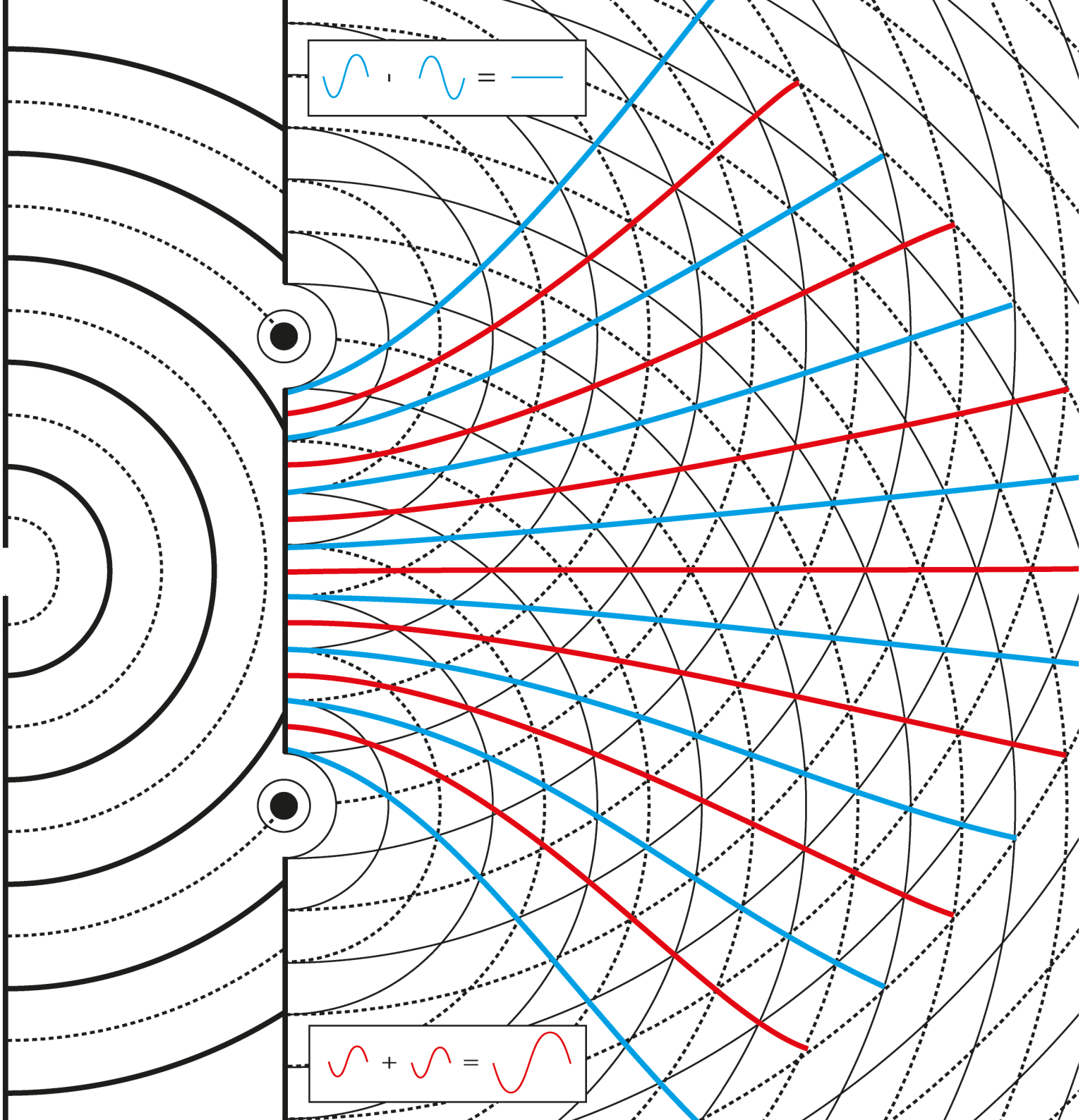

What is Superposition?

"What is The Superposition? Well I think superposition is an interesting word and apt title for what we're trying to do here. A common understanding of superposition is the idea of several things being in the same place at the same time. In one sense that's what we have tonight, we have artists, scientists and makers coming together to see what we can produce and whether we can inspire each other to make and do things we haven't done before.

I've been involved in a collaboration called 'Phase Revival' and found it interesting that artists, scientists and makers interpreted it in different ways and have found interest in its different aspects, they saw it, if you like, in many different states. In quantum mechanics a superposition is an object which is in many different states, it's an object which is both one thing and another at the same time. And yet when you look you can only observe one of those states.

I think that is something art/science collaborations and projects often end up being. One thing seen from many different viewpoints by different people at different times who will see different aspects of them and so, hopefully, there is some sort of link between the word 'superposition', the concept in physics and what we are trying to achieve here in terms of making things which have many different facets and different aspects too."

Transcribed from the introduction by Mike Nix at the first Superposition evening event.

Superposition:

The combination of two or more physical states, such as waves, to form a new physical state in accordance with this principle.

www.dictionary.com/browse/superposition

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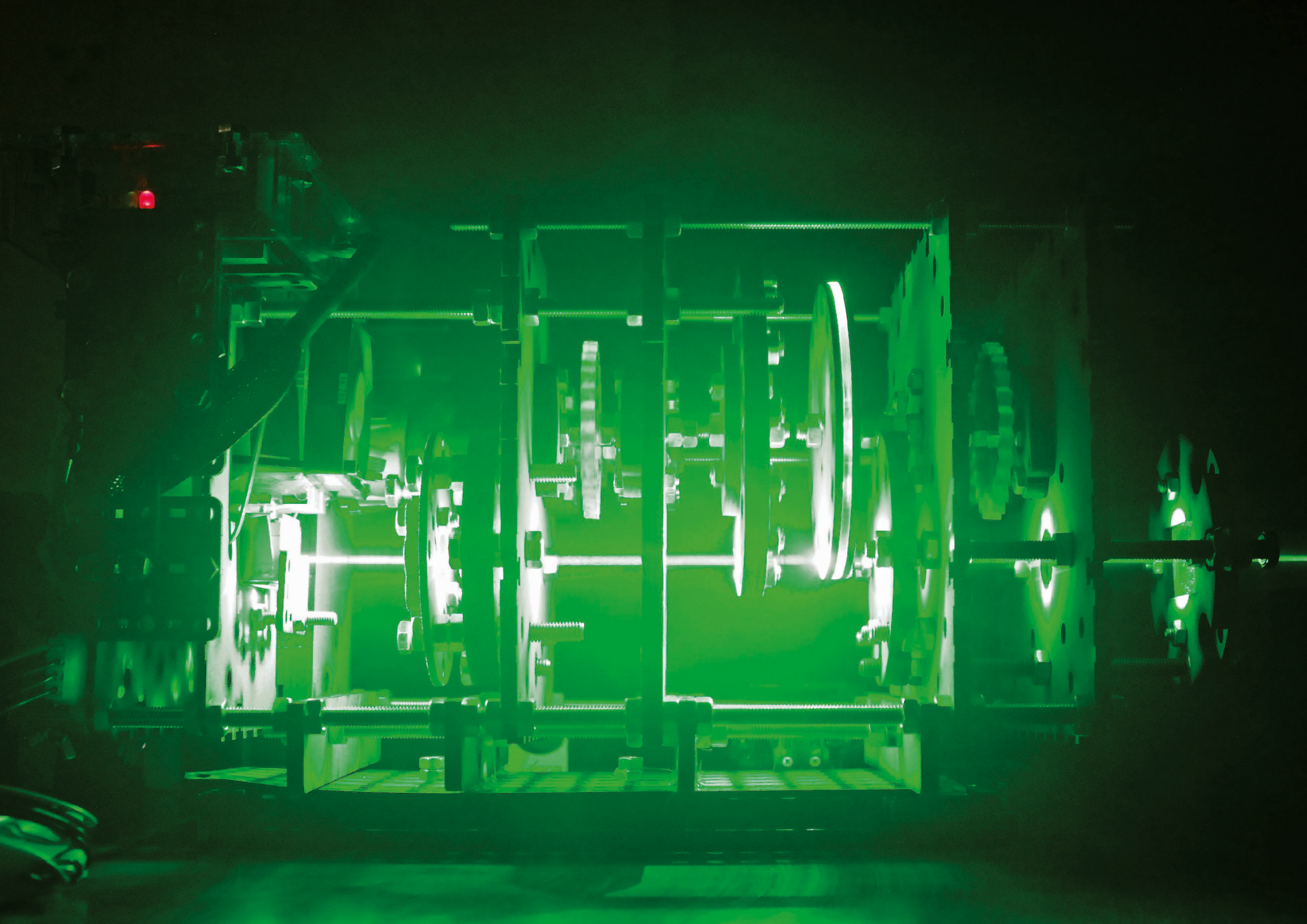

Introduction:
Expanded Vocabularies

Dr. Sam Illingworth

The limits of my language mean the limits of my world.
Ludwig Wittgenstein

In the contested territories of intellectual thought and experimentation, who has the right to tell us how to best make sense of the world in which we live? Artists? Scientists? Both? Neither?

The essays that are collected in this book present an honest account of interdisciplinary research between artists and scientists. By exhibiting these views, and exploring the language that is used by practitioners in both fields we are presented with an opportunity to explore the lifeworlds of both the individual and the collective. This might be through a straightforward comparison of perspectives, such as that offered by Paul Beales and Jim Bond in *'Vessel: Collaboration Through Commission'*, or through an invitation to re-consider and challenge the hierarchies of status that Joanna Leng and Wes Sharrock acknowledge in *'Inclusivity, Continuous Personal Development and the New Economy'*.

In reading these essays, it becomes clear that both the scientists and the artists who are involved in these collaborations are willing to acknowledge and address how personal perspectives have become more complex, challenging, and yet ultimately complete by considering the language of other disciplines and practitioners. As Dominic Hopkinson points out in one of his essays, *"asking questions is what both artists and scientists do for a living."* There is, however, seldom only one answer to any given question, and one of the most impressive accomplishments of the authors of these essays is their willingness to consider the vulnerabilities of personal truths in their collective quest for knowledge.

It is not only the search for knowledge that demands honesty. In his essay *'Why I argued for the development of an exhibition that included non-members and a free workshop programme'*, Lawrence Molloy talks about the need to diversify beyond the usual suspects, with equality and diversity in art and science a fundamental issue that needs to be addressed both openly and honestly. By excluding certain people from learning our languages we are not only denying them access to our worlds, but we are also denying our worlds access to their knowledge, creativity, and potential.

Given that I have argued about the importance for honesty, I should acknowledge that whilst I greatly enjoyed reading all of the essays that are collected in this book, I do not agree with all of the statements that they contain. To (unfairly) pick on one example, I would disagree with Dominic Hopkinson's statement that *"the Scientific Process is the same as the Artistic Process"*, as I believe that whilst there are similarities there are also fundamental differences, and that it is these differences that make interdisciplinary collaborations so effective. This is not to say that Hopkinson's opinion is incorrect of course, only that I have a different perspective on this issue because of my own experiences. Similarly, many people will disagree with some (or all) of the thoughts that I have expressed in this foreword when viewed through the lenses of their own lifeworlds. Such dissent should not only be tolerated, it should be actively encouraged; the confidence to express your own viewpoints is, after all, part of the fun of learning a new language.

In *'Weaving Proteins'*, Lorna Dougan states that: *"We were interested in experimenting with different rule sets for translating the language used to describe weaving to that of structural descriptions of proteins."*

However, I would instead argue that the language of art or science does not need to be translated, but rather that several interpretations are required in order to fully make sense of what is being communicated. Einstein realized this, and when talking about the wave-particle duality of light he stated that *"It seems as though we must use sometimes the one theory and sometimes the other, while at times we may use either. We are faced with a new kind of difficulty. We have two contradictory pictures of reality; separately neither of them fully explains the phenomena of light, but together they do."*

The same can be said of the languages that we use in art and science; separately neither of them fully explains or makes sense of the world in which we live, but together they offer the potential for greater understanding. Such understanding is not instantaneous; it takes time to fully engage with the process of working within art and science to gain a deeper understanding beyond simply responding to the work of different disciplines, and this is reflected here. The essays in this book are representative of artists and scientists at different stages of collaboration, and at different times of the collective; tracking these different states is conducive to understanding the potentials (and limits) for truly interdisciplinary collaborations.

In considering these interdisciplinary collaborations I have focused on art and science, excluding a role that is fundamental to The Superposition: the maker. A role for which, in *'An Evolution of the Maker'*, Dave Lynch offers the following definition: *"A collaborator is a person/group who brings experience which forms a key element to understanding the journey of the project."*

This definition highlights the vital role that the maker plays in any interdisciplinary collaboration, not only offering their own unique skillsets and expertise, but to a large extent providing the common ground and language that can help artists and scientists to develop and expand their own lexicons.

To return to the question that I posed at the beginning of this foreword: no one has the right to tell us how we should interpret the world, but by being introduced to the languages of others we are afforded new vocabularies with which to widen our own investigations. The essays in this book provide a vital guide to how we might begin to expand these vocabularies.

Dr Sam Illingworth - Senior Lecturer in Science Communication;
www.samillingworth.com
August 2018

The Superposition

is a fluctuating network of members, contributors and collaborators.

This book contains some of these voices from the past five years. While it reflects their experiences and involvement, it is by no means a complete history of The Superposition.

By its very nature, the story of The Superposition cannot be contained in any one book.

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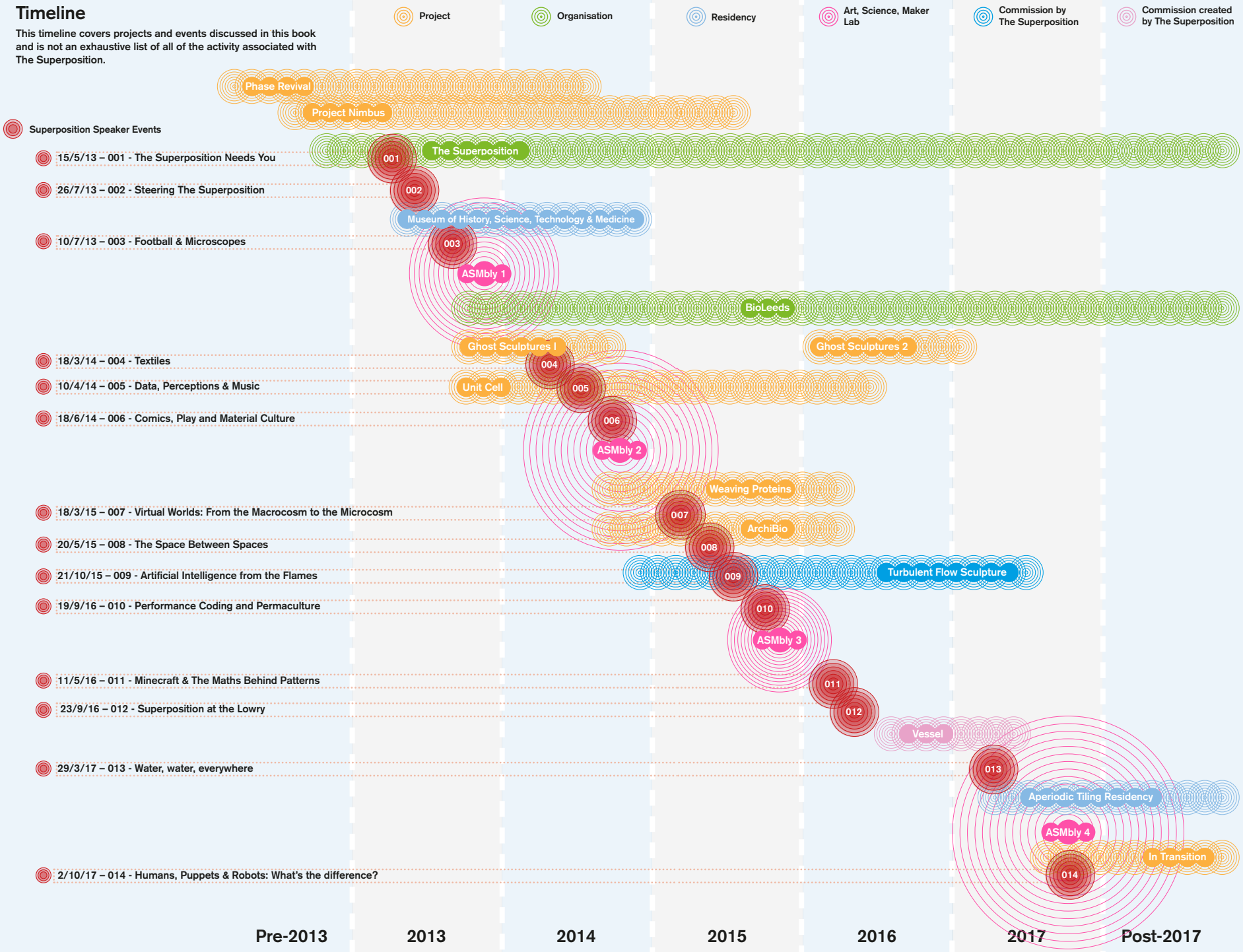
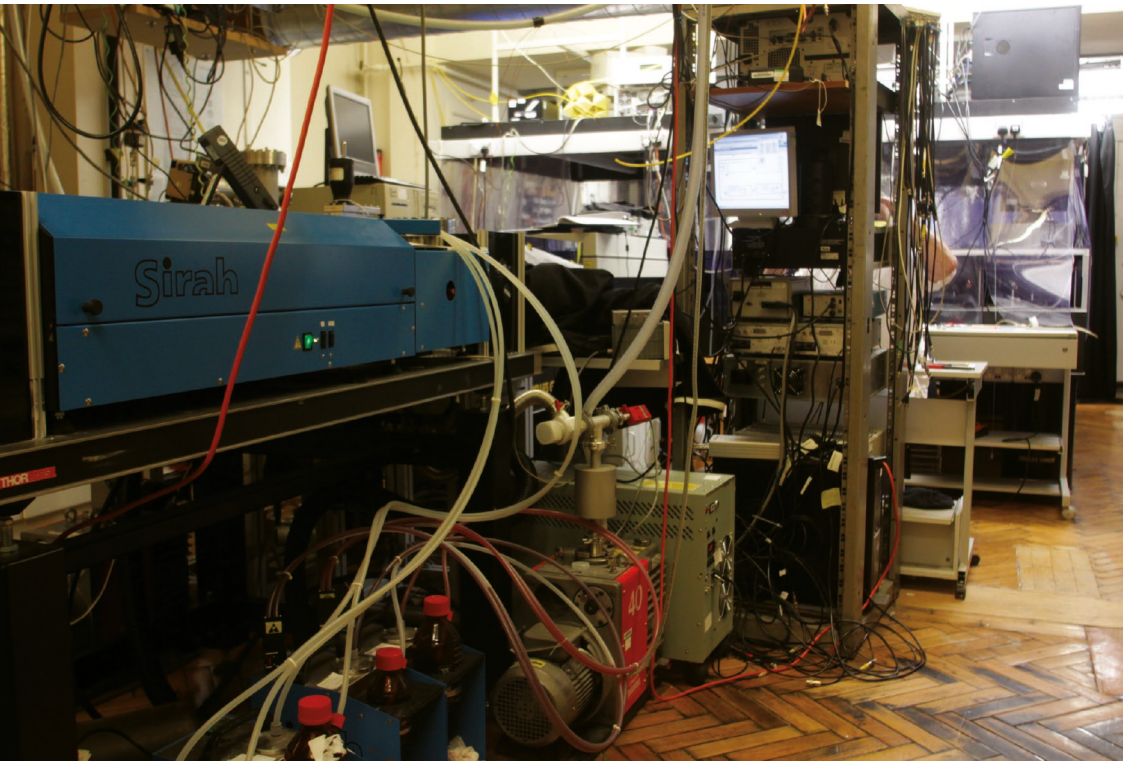
Timeline

This timeline covers projects and events discussed in this book and is not an exhaustive list of all of the activity associated with The Superposition.





A Curious Method for a Sophisticated World

Dr. Joanna Leng
& Prof. Wes Sharrock

Modern research is more sophisticated now than ever. There is more equipment, more materials and the introduction of computing has accelerated the process, breaking down disciplinary boundaries and forming new cross-disciplinary fields.

Cave paintings come from another time, some 40,000 years ago [1], and predates writing which is about 5,000 years old [2]. In the digital age the field of visualization has boomed. The Oxford Dictionary defines it as *"a chart or other image that is created as a visual representation of an object, situation, or set of information"* [3].
When I look at cave paintings I am not sure if they are there purely for aesthetic purposes (artistic expression), or if they are there to communicate knowledge (visualization) for example to aid the identification of plants and animals. There is probably a mixture of both art and visualization, springing from a human need to create, express oneself and communicate. Cave paintings would not have been possible without the ability to make things e.g. paint, containers for the paint, and a means to apply the paint.

The origins of science come from the ancient Greeks, about 2,400 years ago. Science started to resemble what we now think of as science from the time of the Renaissance, 600 to 300 years ago. The Renaissance Man is enlightened in all areas including arts, maths, athletics, philosophy, and history and performed brilliantly in all. He was a gentleman. Until recently, scientists did not work in teams. This is now encouraged by the Research Councils and is necessary because of the sophisticated nature of modern science. What is different about The Superposition is that artists are now also working in teams and are joining scientific teams. The Renaissance Man is now a team (the Renaissance team was a visualization design method developed by Donna Cox in the 1980's which involved a scientist, artist and computer graphics programmer working together).

At the end of the Renaissance, the Salon became an important way to meet, inspire, amuse and transfer knowledge. Later the English coffeehouses became a social place for gentlemen to meet for serious conversation. The Superposition evenings of talks are similar to the Salons and coffeehouses as they provide an environment for serious conversations (even when they are very funny) and encourage people to be active, following their curiosity rather than passively sitting in front of the TV or reading the papers. Over the centuries formal methods have developed for art, science and making (or engineering) but each is based on developing curiosity.

The Superposition is a collective for artists, scientists and makers.

The collective holds no assets or facilities. The group do not fund any activities but facilitate networking and relationships so that works that use skills and expertise from art, science and making can be created and exhibited.

The activities of The Superposition

An evening that consists of 3 talks that last for 20 minutes based on a common theme. One talk is given by a scientist, one by an artist and one by a maker (or engineer). Recent themes include water management and a comparison of humans, robots and puppets.
We aim to do 4 of these a year.

ASMbly is an annual event that lasts between 5 days to 12 days and so far has been held in disused shops. As ASMbly has become bigger there has been a growing need for organisation to arrange it, a front of house presence to welcome participants and visitors and a team to set the space up and clear it away. The format varies but generally includes:

- o An exhibition space;
- o Lab space for individuals & groups;
- o Workshops, activities that are guided;
- o Activities are available but without guidance from a person;
- o Talks and meetings, these include an evening of talks as well as opening events, networking events or planning meetings;
- o A final show that involves novel performances.

A later addition is the “idea generating” meetings which are also called sandpit events, a term commonly used in academia for a similar activity.

- o People are invited to give an even mix of artists to scientists to makers and is generally held about 6 months before an ASMbly.
- o The meeting starts with a ‘show and tell’ - each person brings an object that represents something important to them.
- o Then in turn each person comes up with a novel idea or something that interests them. If this is the first time it has been suggested it is written on a post-it. This ends when there are no more ideas from the majority of people in attendance.
- o The group then works together to separate the ideas into themes. 3 to 5 themes are selected and allocated to a table.
- o The group then splits into sub-groups and sits around one of the tables. They generate ideas for projects on this theme, although they can go off topic. The members of groups swap around until they have been in a group with all of the others who are not in the same de mographic as them ie artists, scientists or makers.
- o The event finishes with the whole group discussing all the possible projects and reviewing the themes.
- o The possible projects are put into a Google Doc and the web address is shared with the whole group. Over the next few weeks the participants can leave their contact details by projects that they are interested in. New teams can then form around these project areas. More projects generally result if follow-on meetings are organised for the whole group.

[1] https://www.newscientist.com/article/dn21925-oldest-confirmed-cave-art-is-a-single-red-dot/
[2] http://www.britishmuseum.org/explore/themes/writing/historic_writing.aspx
[3] https://en.oxforddictionaries.com/definition/visualization

What is the Colour of an Atom?

Dr. D.A. Quiñones

If during a game of pool you hit the cue ball into another ball, you would expect that they would bounce from each other; skilled players are even capable of predicting the direction and speed of the balls after their collision with exceptional precision. Even if you have never used that particular set of balls or played the game before, you would have some idea of the outcome of the interaction. What you would never expect is that one of the balls suddenly disappears, or that they would explode after touching. But how can you be so sure if you have never tested those particular bodies? You can because of previous experience playing the game, watching it on TV or participating in sport with a similar set of objects.

Science is born from observation: you witness a phenomenon, and then you try to describe it, to explain it, to determine its cause and/or effects. You test your hypothesis and generate knowledge from the results of your experiments. This knowledge can then be applied or transferred to similar events, which allows you to make predictions about future outcomes. This is the same for almost all cases, but when the scale of the events is beyond our senses, too big or too small, too fast or too slow, we are no longer able to perceive them. At the point when observation is no longer possible, mathematics starts defining the behaviour of the natural world, giving rise to completely abstract notions.

In order to get a better grasp on these concepts, it is important to draw similarities or create analogies from events that we are more familiar with. For instance, what does an atom look like? Rather than a technical question, this is meant to examine what vision pops inside your head when you try to imagine the abstraction that is an atom. Probably this mental picture is a model in which a small sphere, the electron, moves around a bigger sphere, the nucleus. We learn about this early in school, helping us to understand some of the properties of the atoms. It is also pretty simple to explain, moreover if you use the analogy of the moon orbiting the earth. Now I ask, what do you think would happen if I throw one of these tiny marble-like spheres that make the atom into another one? Whatever you are imagining at this moment is very close to reality, I can assure you. So even without formal training in physics or using complex maths you can make sensible predictions about the outcomes of this thought experiment.

The problem is that it is not always possible to apply analogies to visualise or understand some of the more complex theoretical models. Take for example one of the most important, and controversial, theories of modern physics: quantum mechanics. Here our simple atomic model is no longer accurate: the electron is not actually moving around the nucleus; even worse, it is not at any specific position. This goes against our daily intuition; for sure the electron has to be somewhere, right? And we should be able to follow it moving nearby the nucleus, or can we?

Philosophy aside, quantum mechanics tells us otherwise, so we can no longer paint an intuitive picture of the atom. The most that we can do is plot the probability of finding the electron at a certain point, obtaining some odd figures.

In the previous example, maths helps us to draw some depictions of the system, but even this is not always the case as not all formulas give coordinates or values about perceptible properties. When this happens, there is only one thing we can rely on: art. When you read news or explainer articles about some phenomenon or finding, you will see most of the times artistic representations about some of the notions behind it, even when these are about something completely abstract. An example in quantum mechanics is the representation of the concept of entanglement, in which two particles share an indivisible amount of information. This is sometimes presented as the particles being linked by a string that can be stretched to any degree. The string doesn't exist, but the image gives us a feeling of the particles sharing something, being more than the sum of each one, connected no matter how far they are from the other. Scientific illustrations are significant because they allow researchers to share and explain their results and conclusions. Artistic ones, on the other hand, are helpful to scientists because they allow visualizing and generating an intuition about models and their implications. Art is therefore complementary to sciences because it facilitates the transmission of ideas and the understanding of abstract constructs.

It is easy to see how art can be valuable for sciences, but this is not a one-way street. Collaborations between artists and scientists have resulted in the creation of a new type of works: science-inspired art. This is not an outrageous concept, as there are many parallels between art and sciences: Art is the reproduction of the natural world, science is the description of the laws of nature. Art is the expression of thoughts, science is the generation of ideas. Art and sciences are part of humanity's history, they shape human culture, they evolve, they originate from human mind. The source of any form of art is inspiration, and sciences can certainly provide it.

In Phase

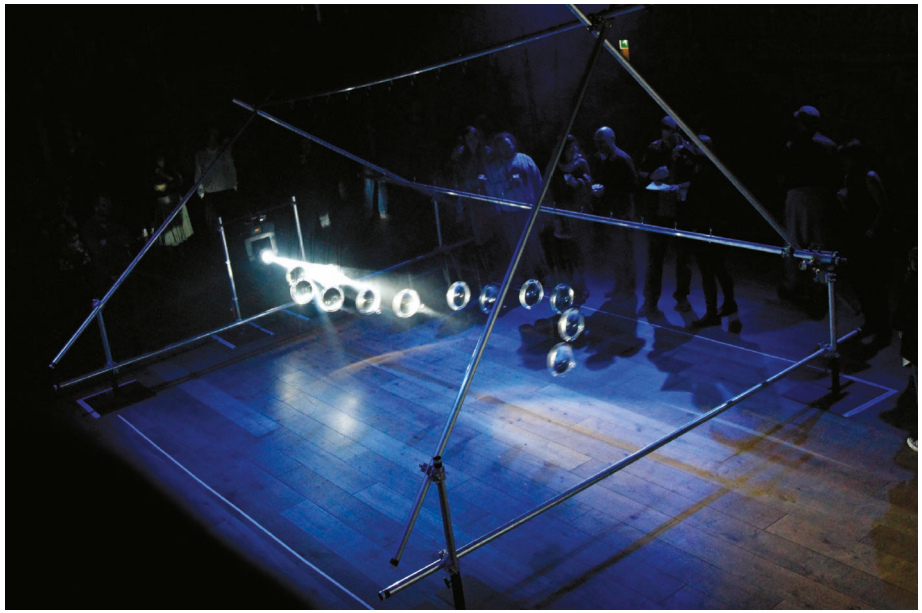
Dave Lynch

In the summer of 2011, as research for an Arts@Cern application, Becs Andrews and Dave Lynch took their artistic experiments with lenses and light to the chemical physicists Prof. Ben Whitaker and Dr. Mike Nix in their underground laser lab at the University of Leeds. Sharing artistic and scientific experiments revealed Ben was a lover of the situationists and a maker of sculptural mobiles. Mike had a background in theatre and both Dave and Becs chose to focus on art over science earlier in their education. From our different trajectories, we all shared a dissatisfaction for traditional forms of science outreach or as Ben calls it *'face painting'*. Inspired, we embarked on a collaboration to create something different with a small outreach grant from The Royal Society of Chemistry.

Discussions focusing on the research of the chemists ensued, half at the University, half through Project Nimbus experiments every other Friday, swiftly followed by the other half in the Pack Horse Pub at 6pm. Over a year of discussions elapsed leaving us uninspired with zero ideas. Following Becs' lead we returned to explore the original experiments with lenses and light in a theatre environment. After 20 minutes of play with lenses, projectors, diffraction gratings, CDs and talk of pendulums echoing in the space, Mike had the idea for *Phase Revival: An Optical Harmonica.*

Two months later, one cloudy December night in 2012, something was swinging in the darkness. A spreadsheet of calculations has the structure of scaffold poles, with perfectly spaced, 8mm holes. 12 saucer-sized lenses float, in laser cut holders, from ropes stepped in exact(ish) lengths. Shrouded by darkness in a rising field of haze, a single beam of light slices the atmosphere like a distant lighthouse. The 12 glass pendulums are gently hooked at 45 degrees, poised to swing on command. The scene is set for the arrival of the only fixed element of the piece.

Derived from the mathematics which governed the physics of the 12 swinging pendulums, sound artist Jon Hughes created a 12 minute musical score and with it, a fixed moment in time to release the pendulums. A moment that synchronised the score's individual chimes as each of the 12 pendular reached the lowest part of their swing. An audiovisual coherence manifested directly through physics alone. This timed release gave a performative element to the installation, synchronising human precision with the physical and sonic patterns of a phase revival. The first showing of around a dozen 12 minute phase revivals was encountered by a handful of audience members from across Leeds University and beyond. It inspired interdisciplinary conversations about the physics of different lens setups, ideas for musi-



cal performance, film projection and interactive artworks. An exploratory conversation between art and science was beginning. A short film was made of this first showcase and presented at the Royal Society of Chemistry's annual meeting and the first Superposition evening alongside a talk about our collaborative journey and process.

We installed the sculpture for further experimentation and play at the inaugural ASMbly Lab in preparation for a showing at Light Night Leeds. Critical to this second showcase was the decision following Ben's lead inspired by the situationists - zero explanation before or in the performance space. Audiences entered the atmosphere of the installation with little knowledge or expectation. As they exited, the team were present to answer their questions, usually discussing that the patterns formed by the pendulums were part of nature and the musical tones were not triggered digitally as each pendular passes through the light, their synchronisation is governed by the same mathematics. This opened interest and discussions into the spectroscopy work of Ben and Mike through our approach of scaling the quantum world to the human experience. Expectedly audiences were perplexed. Unexpectedly, they queued again (sometimes several times) to re-enter the space and audiences began to share this knowledge between each other in the space. In the end, the installation saw 6000 visits over 4 hours and was described by Lawrence Molloy as *'experiential outreach'.*

On reflection, there are multiple ways to deconstruct our collaborative process and the multiple successes of the project, yet reconstruction would certainly not replicate these outcomes. Putting our different disciplines, languages, statuses and backgrounds aside, it was our openness as individuals which mattered and in turn embodied trust and independence for each of us as thinkers and contributors - *people work with people.*

Sure, we shared a joy in discovery and an appreciation of understanding the world through science and art yet it was our personal histories and first hand experiences which created the value for each other's processes. This value sparked our aptitude for serious play though doing. The openness created an environment where we could (and all did) ask really, profoundly unintelligent questions and even celebrated it when Mike said 'NO!' as there are no bad ideas in the spirit of collaboration. This spirit became infectious so much so, that one evening in late 2012, 5 people got together in the Pack Horse Pub at around 6pm and conceived of an experiment to see if a community would come together around the spirit of collaboration; The Superposition was born.

In memory of Becs, without her, we wouldn't be where we are today.
[Becs Andrews 1978 - 2016]

The Art of Science Engagement

Dr. Paul Beales

While I am not unique in my approach, it is a path far less travelled than many other public engagement routes, and so I'd like to reflect on my experiences and my personal views on the advantages of art–science collaboration.

Impact is a buzzword in UK academia, not for the impact of your science in your field but for how you gain broader impact in communities. I have been very fortunate to be able to engage with a vibrant community of artists, scientists and makers in Leeds interested in multidisciplinary collaboration – The Superposition. Science-inspired art is much more than public engagement. The process of discussing your favourite scientific ideas and concepts with an artist and engaging with their responses to these can be enlightening. Artists will often come from very different viewpoints than a scientist traditionally would. This can help you see familiar concepts in new lights and has the potential to reshape thinking in ways that will nucleate fresh, original ideas about your scientific practise and directions in which your research might develop. While the wider public probably do not view science as a creative pursuit, like they do art, it certainly is at the leading edge of research in a field. Therefore the process of engagement with an artist and the process of developing collaborative ideas is just as important as the final output and its exhibition: the journey is just as important as the destination. Critically, process is also of utmost importance to the artist. Art should not be seen as a route to teach people scientific concepts.

Familiarity and comfort with science prevents some of the fear and mistrust from the public that can lead to negative public opinions of technologies such as GM food, fracking and nuclear power, usually based on weak or no scientific evidence. To reverse these trends, particularly for future potentially controversial technologies, we need to bring the wider public with us and get them on-board and comfortable with them. Having presented science-inspired art at several events, some members of the public want to get in-depth explanation of the science, while others are happy to draw their own parallels and ideas knowing there is a scientific concept behind the piece but not worrying about needing to understand this in any depth. Both of these perceptions are important and beneficial.

Collaboration with artists takes time and patience. You are unlikely to get it right first time. I found my early engagement challenging. I was too keen to be providing creative, artistic input to the process but was held back by my scientific instincts of being precise and worrying about details and nuance. Science-inspired art doesn't need to be scientifically accurate, just based on a scientific idea with artist interpretation; this is best left to the artists! The role of the scientist is to clearly communicate concepts, discussing ideas in a clear and understandable language that interests and inspires the artist to create.

Adapted from: *https://academicdad-blog.wordpress.com/2017/11/12/the-art-of-science-engagement/*

How to Find Solutions When You Don't Know the Questions

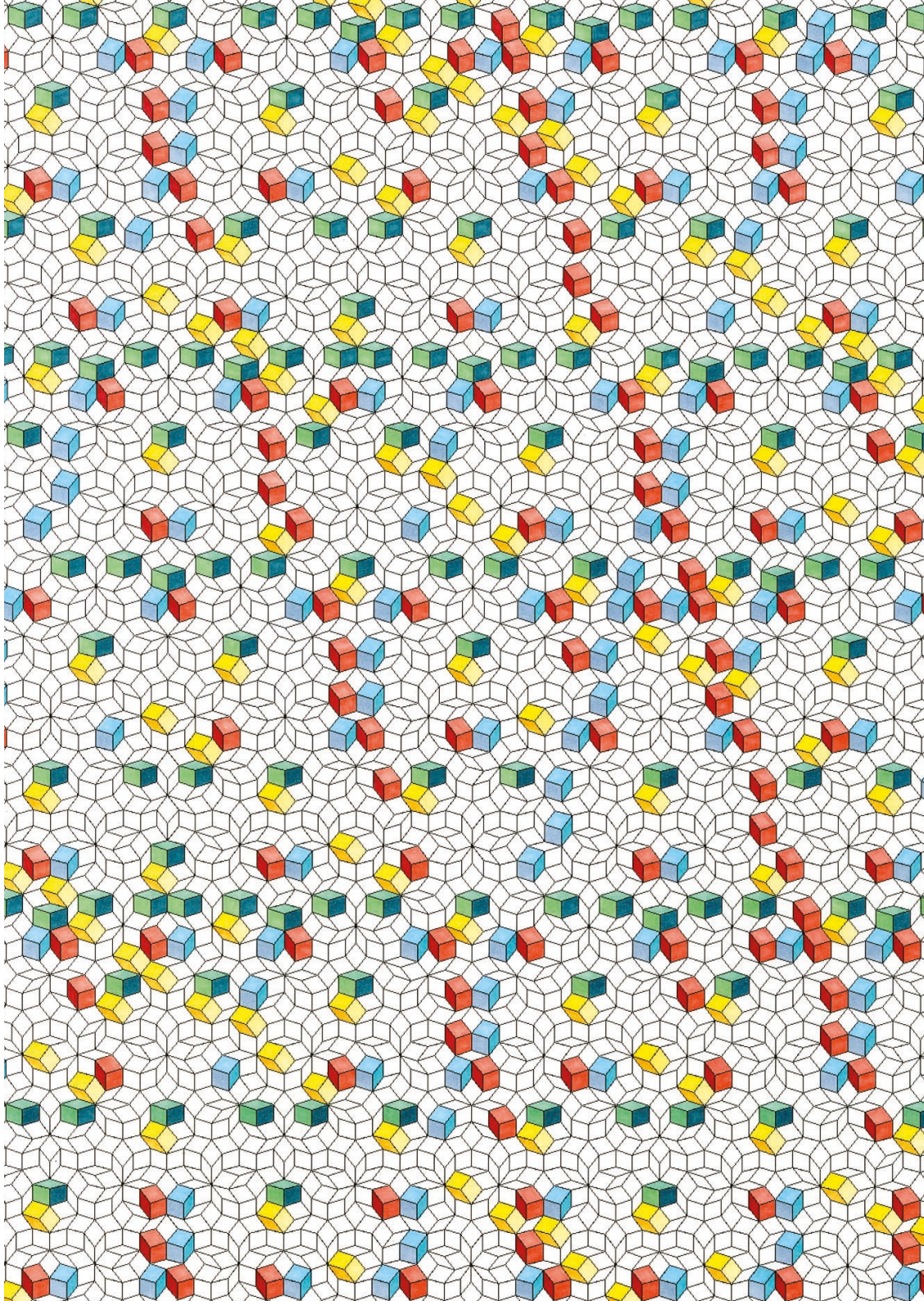
Dominic Hopkinson

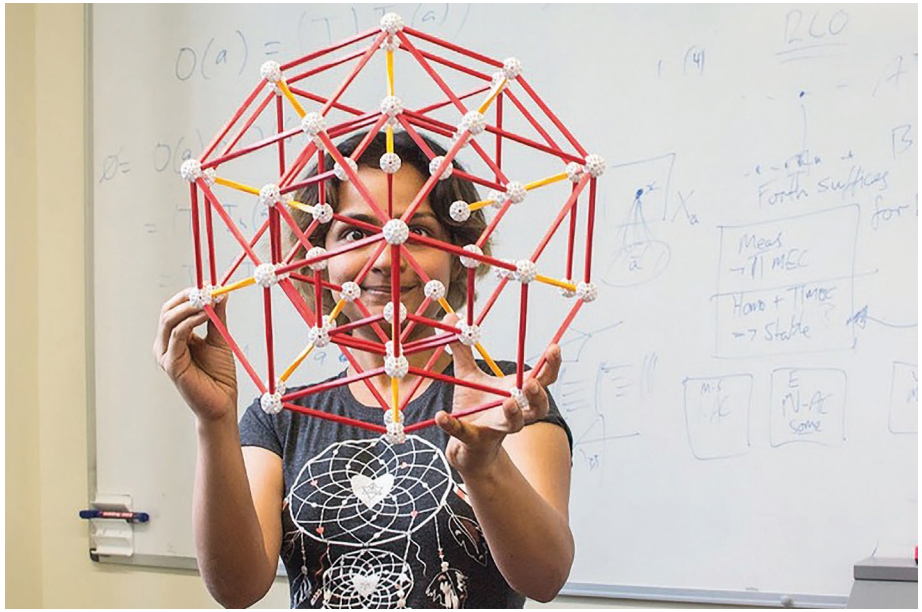
The idea that artists want to work with scientists comes as something of a surprise to people, including artists and scientists, yet to those artists involved in The Superposition it is an obvious solution. Most of the artists involved in The Superposition were already interested in certain aspects of scientific endeavor, looking for a chance to formalise their relationships with scientists of all persuasions.

I have been Arts Council funded as the artist in residence at the School of Mathematics at The University of Leeds for a year, a role that causes great confusion and consternation whenever I discuss it. Many mathematicians don't realize that a non-specialist can have a deep interest in their work, whilst being singularly incapable of "doing" the subject, (I achieved, if that's the right word, a grade C at O Level 30 years ago), but this does not stop me from being inspired and fascinated by what mathematicians routinely work on. Equally, non-mathematicians don't initially equate art with mathematics.

My own interest is in aperiodic tiling systems in 2 and 3 dimensional space, a subject that leaves most people blank, yet holds within it questions regarding the role of maths in the auto-generation of three dimensional structure in systems as diverse as atomic lattices, cloud formation, the large scale structure of matter in the universe, why leopards have spots and zebras have stripes, and much else besides. As a sculptor, it seems obvious to me that mathematics potentially has the ability to provide inspiration, insights and answers into the very fabric of my process. How does structure form? What are the underlying mathematical principles that govern this process? And can I utilize these processes to inform my own creative sculptural process? The mathematician Walter Warwick Sawyer described maths as "the classification and study of all possible patterns", while the Encyclopaedia Britannica describes maths as "The science of structure, order, and relation that has evolved from elemental practices of counting, measuring, and describing the shapes of objects."

Recognizing that the intellectual approach of scientists is the same as an artist is the first step in understanding why we want to collaborate. Research is a word not normally associated with the artistic approach, creativity, inspiration and even invention probably more readily spring to mind. Yet artists undertake research in a myriad of forms, be it subject matter, materials, process or techniques, and equally conduct experiments into composition, form, structure and content that are directly analogous to the role of a scientist.





Development by incremental iteration, regular failure, being driven to new thinking by one's experimental results… am I describing a scientific process or an artistic one? Once a scientist realizes this fundamental state of affairs it becomes simple for them to recognize creativity in their own process but also how beneficial a collaboration can be for both parties.

The major difference comes in the initial state. I generalize, (something scientists do less than artists (another generalization)), but usually scientists have a question or idea that they are attempting to find solutions for. Their initial state is at least informed by some sort of structured, informed problem, that has a potential path to solution. Artists, on the other hand, are in the fortunate and unusual position of not always requiring any initial state, we are not necessarily governed by any intellectual conditions, we can theoretically make, or do, what we like. Yet the difference is wider than just this. Artists feel at liberty to ask questions they don't know the answers to, or ask questions they don't even understand, or ask questions that don't even have "answers". Artists are comfortable beginning a research process without understanding the question or knowing how to begin trying to find out the answers. We are terribly arrogant of our ability to generate some sort of informed outcome based on such nebulous initial states! Yet the field of mathematics is closer to this approach than most other sciences; as Bertrand Russell said in 1901, Mathematics is *"The subject in which we never know what we are talking about, nor whether what we are saying is true."*

Asking questions is what both artists and scientists do for a living, so why not work together to find solutions? Asking scientists questions based on limited or zero knowledge is highly entertaining, not least because you learn how to ask "good" questions, even if you don't know what you are talking about. Yet scientists are pleasantly surprised that artists can, and do, ask questions that make them think.

Asking a physicist to explain quantum mechanics in the time it takes to drink a pint forces them to refine their arguments and thinking so that we can understand what they say, even if we still can't understand what they mean. Working together enhances each individual's critical thinking, opens them up to new ways of thinking, doing, making and experimenting. A true art-science collaboration should be a two-way street; information, ideas, techniques and approaches should be shared and utilised as an ongoing process where the outcomes of one is more similar than different to the outcomes of the other. Creativity is the key to this approach. Recognising that theoretical mathematicians, molecular biologists or geologists all share huge areas of overlapping cognitive and haptic skills with artists is recognizing that the Scientific Process is the same as the Artistic Process.

An Evolution of the Maker

Dave Lynch

Art-science collaborations can be trans-actional exchanges. Art uses science for novel applications in production and process; science uses art as a method of communicating scientific concepts to the public; and both these interactions have value. However, some collaborations seek to go beyond these short one-way relationships to form a dialogue between scientist and artist.

Over time each discipline can form a complex understanding of the others' modes of critical and creative thinking in both approach and process. Good practice can lead to *knowledge integration and a synthesis of approaches* termed interdisciplinary collaboration. Further still, is the search for *a unity of intellectual frameworks beyond disciplinary perspectives,* known as Trans-collaboration [1]. This blurring of disciplines can lead to a single novel hybrid discipline.

Importantly the function of these hybrid, trans-collaborative dialogues is not to communicate to audiences or colleagues, it is a unique space to design new languages and approaches that ask novel questions of critical interest to the instigators. For me, one of the most interesting outputs of The Superposition is a series of models which have this search for trans-collaboration in common, observed through the disciplines of art, science and making. This triad resonates differently for everyone who engages with the collective. Here, I share why I think it is important in this search, that makers are acknowledged and consider how the definition of the term maker has evolved from my perspective.

Art as Research

When engaged in research as an artist, novel techniques, technologies or processes can distract the focus of the artistic process especially the method and outcomes are deliberately undefined. By defining the roles of the scientist and maker in the research process, we by default define the role of the artist. This gives artists means and space to critically reflect in the maelstrom of meandering collaboration. In turn, this enables artists to engage in research whilst making something beautiful; and to critically explore with collaborators and audiences a deeper process of exploring-through-doing. The process of exploring through doing enables artists to engage in the research whilst making something beautiful. Artworks finished or not, can be vehicles for discussion to critically explore ideas with collaborators and audiences.

The Maker Movement gained force in 2005, with the advent of O'Reilly's 'MAKE' magazine and Maker Faires, encapsulated as a social movement with an emphasis on learning-through-doing. For The Superposition's triad, the inspiration to separate the maker came from collaborating with a multi-talented force called Aaron Nielsen of oomlout.co.uk, who I met at the UK's first Maker Faire in Newcastle in 2009. Aaron creates through technology, and identifies as many things but certainly not an artist or scientist.

Aaron was fundamental in the creation of the laser zoopraxiscope (page 3-4) a remake of the first motion picture projector by Edweard Muybridge (1887) which was used to project moving images onto clouds from aircraft in Project Nimbus. In a talk about Phase Revival in mid-2012, inspired by Aaron's role as the maker of the pendulums' holders and laser zoopraxiscope, I defined the role of the maker as:

"The obscured yet often critical role in the creation of art or science."

Subsequent stories of makers obscured by history ensued. Professor Ben Whitaker spoke of Robert Hooke's instrument maker and Christopher Cock who made the first microscope [2]. Muybridge's first photograph at a 1000th of a second was due to the engineer, John Isaac's electrical camera shutter [3]. This critical role of the maker, who exists with the desire to play, tinker and create has an exploratory mode of critical-thinking-through-doing, which is a fundamental part of many art or science projects from the outset. With this in mind the founding members of The Superposition made a conscious decision to acknowledge this when exploring art-science collaborations. On some projects, someone may collaborate as an artist or scientist while on other projects that same person may collaborate as a maker. This also enables others who identify as makers to co-create art and science projects from the outset.

During the 5 years of *Project Nimbus* (2011-15), the makers included: weapons experts, aviators, 16mm film makers, product designers, technologists, cultural theorists, solicitors and many more who brought creative and critical contributions. Not all were practically minded, which led me to the conclusion that the maker can be seen as a separate discipline, standing distinctly on its own, defined as: *"Any expert who was key to 'making it happen' separate to the art or science."*

A further fundamental shift in my understanding of the maker was inspired by the pilot who flew the plane for *Project Nimbus*, as perfecting the angle required for projection which was critical during the final hour. His experience was vital to the project and over the years brought me to understand that a collaborator's discipline is equally as important as their experience whether that comes from their disciplinary background or any other area of their life.

As there is no accepted maker academic discipline or qualification, I can identify them by their experience and drive to create solutions. The maker in a project can be more than any single person, they can be communities or groups of people with a shared experience such as living with the emissions of a volcano, which I discovered while working on the *UNRESP* project in Nicaragua [4]. This led to my next definition of a maker:

"A person/group who brings experience which forms a key element to understanding the journey of a project."

As for *Project Nimbus*, considering and establishing the roles for the makers enabled the art to initiate collaborative research into the human relationship to data; the role of the image in society; ownership of public space; future advertising technologies; and how theoretical US military psychological warfare techniques can be repurposed. The resulting projections on clouds were discussed across international media and even sparked conspiracy theories about breaking the 4th seal of Revelation. In 2016, the project was nominated for the inaugural Ars Electronica STARTS (Science, Technology, Arts) award [5]. I now think of 'maker' as a trans-collaborative verb; an evolving 'doing word' within each project I collaborate on. It enables a dialogue in the search for new knowledge when the disciplines and experiences of art, science and making become blurred, as now any collaborator can become the artist, scientist or maker.

[1] Jensenius, A. (2018). *Disciplinarities: intra, cross, multi, inter, trans.* [online] Personal Blog. Available at: http://www.arj.no/2012/03/12/disciplinarities-2/ [Accessed 16 Jul. 2018].
[2] Muybridge, E., Prodger, P. and Gunning, T. (2003). *Time stands still.* Stanford, Calif: Iris & B. Gerald Cantor Center for Visual Arts at Stanford University, p.145.
[3] W. Davidson, M. (2018). *Molecular Expressions Microscopy Primer: Museum of Microscopy - Hooke's Microscope.* [online] Micro.magnet.fsu.edu. Available at: https://micro.magnet.fsu.edu/primer/museum/hooke.html [Accessed 16 Aug. 2018].
[4] Ilyinskaya, E. (2018). *UNRESP.* [online] Unseen but not unfelt: resilience to persistent volcanic emissions. Available at: https://vumo.cloud/ [Accessed 16 Jun. 2018].
[5] STARTS PRIZE. (2018).*S+T+ARTS = STARTS – Innovation at the Nexus of Science, Technology, and the ARTS.* [online] Available

Following pages:

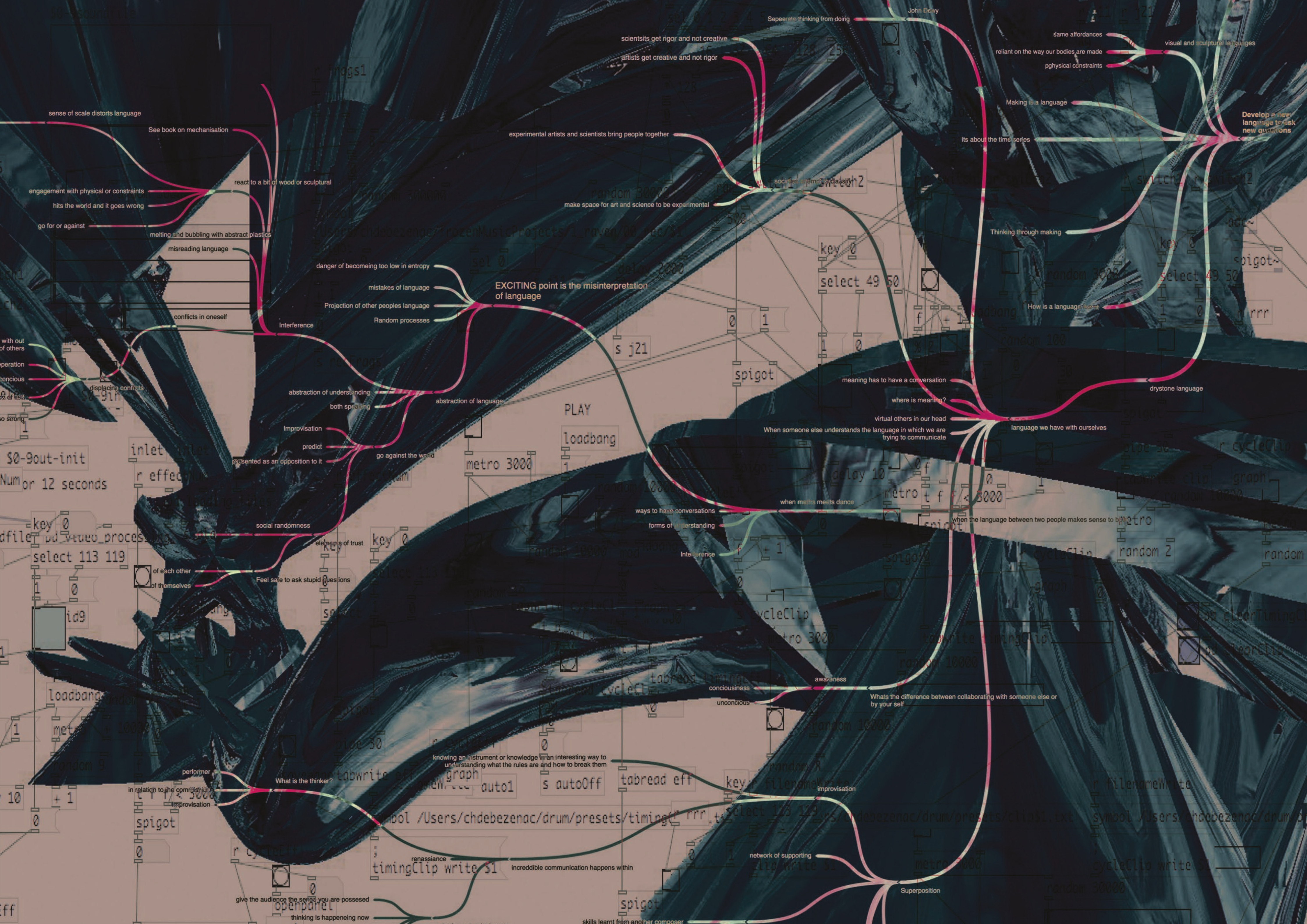
Images, words and code: A visual essay on the nature of collaboration

Adam Glatherine
Dr. Christophe de Bezenac
Dave Lynch

Three people active in Art, Science, and Making visually represent their initial thoughts and reflections from a one-time discussion about the nature of collaboration.

The representation explores ways of manipulating, recording and presenting heterogeneous perspectives through spoken, visual and programming languages.

Specific to both the personal experiences and disciplines, how can these conceptual interconnections randomly overlap to create meaning that inform the next stages of collaboration?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Commissioning Research. Or How it Should be Done

Dominic Hopkinson

When most people think of the process of commissioning a public artwork, they probably assume that the artist is selected on the basis of the strength and suitability of their work, and is given free reign to interpret a fairly open brief. The reality, as most artists quickly discover, is rather different. Invariably, a committee has been set up to “manage” the process, which is made up of project administrators, funders, architects and developers. Many, if not all, of these people have no background in the arts and have little or no interest in the project in its own right. They are just going through the motions because the development brief included a clause requiring the provision of a piece of public art.

What becomes apparent is that this group of people have already set a budget, found a preferred location, chosen a “theme” and have an expectation of delivery that is a million miles away from what is possible given the size of the budget. The artist, the sole member of the process who has specialist knowledge and experience in the process, is left with nothing more to do than to fulfil what is effectively a “fabrication brief”. Build what we want, where we want it, how we want it and to our budget and limited taste!

Usually this means that the work is designed by committee and conforms to the lowest common denominator. This approach is especially troublesome when commissioning a work that incorporates an element of scientific research. Throughout the Superposition process we are aware that art-science collaboration is not a superficial “add-on” to the creative process, but a process that informs every aspect of the design and build stages of an artwork. Because of this, commissioning a piece of art has to take into account what Donald Rumsfeld infamously called “known unknowns”, i.e. those elements of a project that are still very much in the research phase. If commissioners really want to buy into an Art/Science process they have to understand that what they are really commissioning is a research process first, and an artwork “build” second.

The methodologies employed by artists, scientists and makers are incredibly similar; asking questions, formulating how best to answer them, building and testing prototypes and theories, refining the approach and engineering solutions, either theoretically or practically. The use of experimentation through iteration is key to this process, with outcomes only becoming clear as the experimentation progresses. This is also not usually a discrete process; creation and solutions coming at multiple stages along the route, often leading to outcomes not originally expected. Keeping an open mind to possibilities is crucial; having a willingness to be led by the results rather than slavishly following the plan to the letter.

This process is, by its nature, difficult to “manage” and hence often gets ignored by commissioners who only feel comfortable when they can be given specific timelines for the process and who are terrified at losing control not only of the deadline but also of their own “vision” (as rubbish as this might usually be). Providing an approach that embraces all the difficulties associated with a research based method is daunting, and yet is vital in fostering an environment that allows for creativity to flourish from research.

In 2014 Lawrence Molloy, Dr. Mike Nix and myself applied for a commission to develop an interactive, kinetic sculpture for the University of Leeds School of Mathematics. Their specialism is fluid mechanics/dynamics, and they wanted a piece of art that would act as a way of explaining this to the parents of prospective students.

Our original pitch was an extremely ambitious idea to use a binary fluid system that mixed and separated within a temperature gradient to create what we thought of as an enclosed weather system. At the time of the pitch we had no idea of the chance of success, but decided to sell the idea as a research process with something as an outcome! In fact, we told them that we only had about an 80% confidence in our ability to deliver, and that if we failed we would not be able to refund the costs since we would have spent them on materials.

To our great surprise we were successful in getting the commission, despite being up against other artists who had been able to pitch a “finished, off the peg” solution. We agreed to develop a scaled prototype which would be demonstrated to them after three months and the expenditure of 10% of the total budget, a sum we assured them they would never see again if we failed or they didn’t want to continue with the process! They did not bat an eyelid at this!

As our progress developed and the realisation dawned that we were not able to deliver the original idea for technical reasons we iterated our way from one idea to the next. Yet all the time we were concerned at how this was being viewed by our commissioners, the School of Mathematics. Upon discussion with Alastair Rucklidge, the Head of School, we were given a response that I will remember for a long time and recommend to anyone considering commissioning an Art/Science collaboration.

“We are a University, and we should be seen to be commissioning research”.

The University recognised our approach as being in line with their theoretical and experimental ethos and were willing to gamble on an artistic approach being of equal merit and value.

Vessel: Collaboration Through Commission

Dr. Paul Beales & Jim Bond

A different approach to art-science collaboration emerged through a commissioning process. This project was externally funded as part of a Research Council's UK research grant to increase awareness of the research in the wider public.

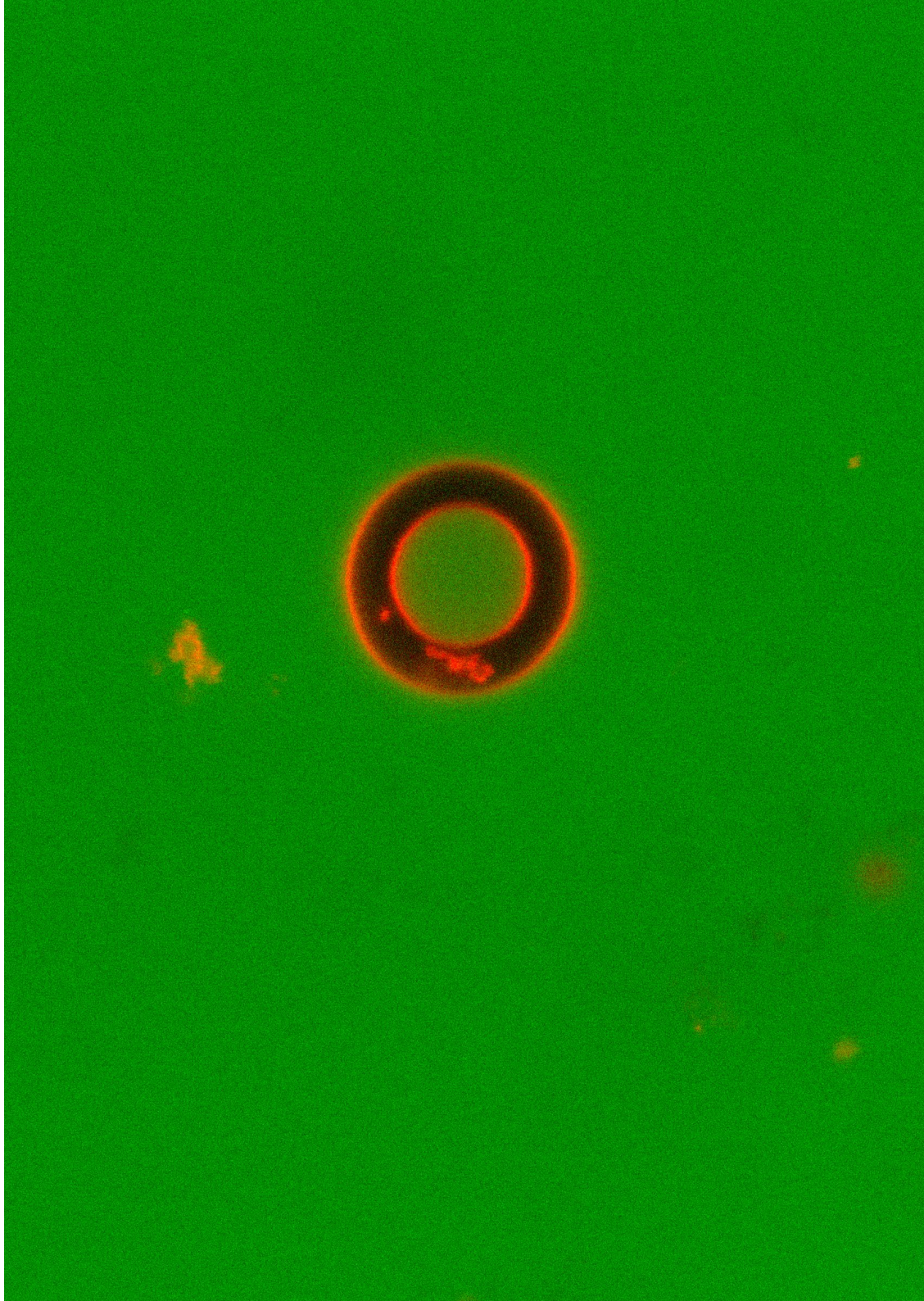
A scientist's view: Dr. Paul Beales

The decision to experiment with a commissioning process was twofold: (i) to give wider exposure of the science within artist communities and therefore, (ii) to receive a broader spectrum of responses inspired by the science. Communicating this opportunity to artist networks couldn't have been done without the expert knowledge of artists and makers in the Superposition, in particular Andy Wilson was instrumental in making the commissioning process a success. Over 50 entries were submitted from artists, some of whom were based internationally.

The challenge was now to pick one! A commissioning panel of scientists (PB and project partner Dr. Barbara Ciani, University of Sheffield) and artists/makers (Andy Wilson, Tom Beesley and Lawrence Molloy) was formed. Initially, the scientists favoured submissions that were more faithful to the science, while artists generally were free of these constraints and favoured pieces purely on their artistic merits. However as the discussions went on over three hours, consensus was gradually reached as the artists came to understand more about the science and the scientists loosened their grip on the necessity of scientific accuracy to successfully communicate these concepts through art. Finally, unanimous agreement was reached to award the commission to kinetic sculptor Jim Bond, based relatively nearby in the West Yorkshire region. And a great decision this turned out to be!

Jim spent time in the lab and in research meetings with the teams in Sheffield and in Leeds. The goal was to produce a piece inspired by the mechanism by which a protein nano-machine bends cellular membranes to create new membrane compartments, a microscale biological process being repurposed by the research team to create artificial cells. Having an artist, a scientific layman, present in the research environment made us reflect on how we discuss and explain the work we are doing and thereby challenging our depth of under-standing that allows us to break down complex ideas into more simple terms.

The resulting artwork produced by Jim, Vessel, has been presented at ASMbly, Light Night Leeds, been on display in the School of Chemistry in Leeds and, in the near future, will feature at bioscience conferences at the Royal Society's Chicheley Hall and a Nobel Laureate symposium in Leeds. Vessel has proven an interesting centre point for discussions of the project with the general public as well as other scientists, demonstrating the versatility



of art in presenting ideas to very different audiences. Public response has likened the piece to an optical illusion, for example, while scientists have drawn connections between Vessel and their own areas of science including the distortion of space-time by spiral galaxies – a completely different length scale to biomolecular processes in a cell. This has led me to revisit concepts in galaxy formation and general relativity to explore the possibility of more tangible links between the underlying science of these two disparate systems.

The artist's view: Jim Bond

As an artist my brief was to create a sculpture based on the work of Paul Beales and Dr. Barbara Ciani into how proteins enter the cell and create compartments. My approach to this Superposition commission was to enter the process with an open mind about the outcome with no preconceptions of what I might produce at the end.

My experience of working with the teams at both Leeds and Sheffield Universities was to be warmly welcomed into a hidden world. My brief was to work on creating imagery based on cell mechanisms which are at the limit of what can be made visible using the highest powered electron microscopes. Despite the obvious challenges I was lucky enough to be given a personal crash course in cell dynamics accompanied by white-board drawings by Dr. Paul Beales with the help of Dr. Andrew Booth. This was extremely helpful in my understanding of what I would later be seeing under the microscope. The time spent with all the different members of the team in their offices and in the lab provided me with an insight which went beyond the normal parameters of research I am able to access as an artist and I was able to gradually form a mental picture of the shapes and forms and structures involved. I was given unique access and enjoyed having the time and space to ask questions which were always answered in a way which was straightforward and clear.

After working through ideas on paper and then creating three dimensional experiments I shared my sketches and then my initial visuals with the team and was pleased with the feedback. In particular Dr. Barbara Ciani said that the visuals I had created of a spiral changing shape using latex and a shadow were better than the computer models they had of the cell wall distortion and could be considered to be science. The resulting kinetic sculpture came very naturally out of the visual descriptions which were so patiently explained to me. A steel circular structure represents the cell and supports a second smaller disc with a stretched latex membrane representing the surface of the cell. The shadow of a rotating copper spiral is projected onto the surface of the latex and this shadow distorts as the membrane is pulled from underneath. I was also pleased by the simplicity of the title which is a reference to GUVs or Giant Unilamellar Vesicles, the empty cells which are created in the lab. This has been a profoundly valuable experience which has contributed to my creative practice and increased my appetite for further collaborative work alongside scientists.

Diffractive Practice

Ben Dalton

What does superposition mean for doing design research? How does this fundamental feature of wave behaviour, and quantum entanglement, relate to the social, aesthetic, political and technical considerations of design practice?

For me it provides a way of working — a diffractive methodology — and a way of understanding — a superposition of ethics, ontology and epistemology. If you know the 'material-discursive' work of philosopher- physicist Karen Barad, the idea of diffraction as a method, and as an 'agential realist' ethico-onto-epistemology will be very familiar. But what does this mean for the critical creative practice found in art and design?

We all have a feeling for diffraction patterns — in the superposition of waves on the surface of a pond, or in the iridescent colours of a soap bubble. In the experiments that illustrate quantum mechanics, diffraction is even more nuanced and profound — passing particles through two slits to produce wave-like diffraction patterns of entangled states for example, or recording and then later erasing the path of particles to constitute new entangled diffraction patterns.

Karen Barad draws together this understanding of diffraction in quantum mechanics, what she calls *"the best physical theories we currently have"*, with an understanding of diffraction as a method of critical sociology and feminist science studies — *"our best social and political theories"*. In particular she extends Donna Haraway's use of diffraction as a counterpoint to reflection, to implicate researchers within phenomena they study and as part of the exclusions and power imbalances enacted. In her book, Meeting the Universe Halfway, Barad argues that *"we can understand diffraction patterns — as patterns of difference that make a difference — to be the fundamental constituents that make up the world"*.

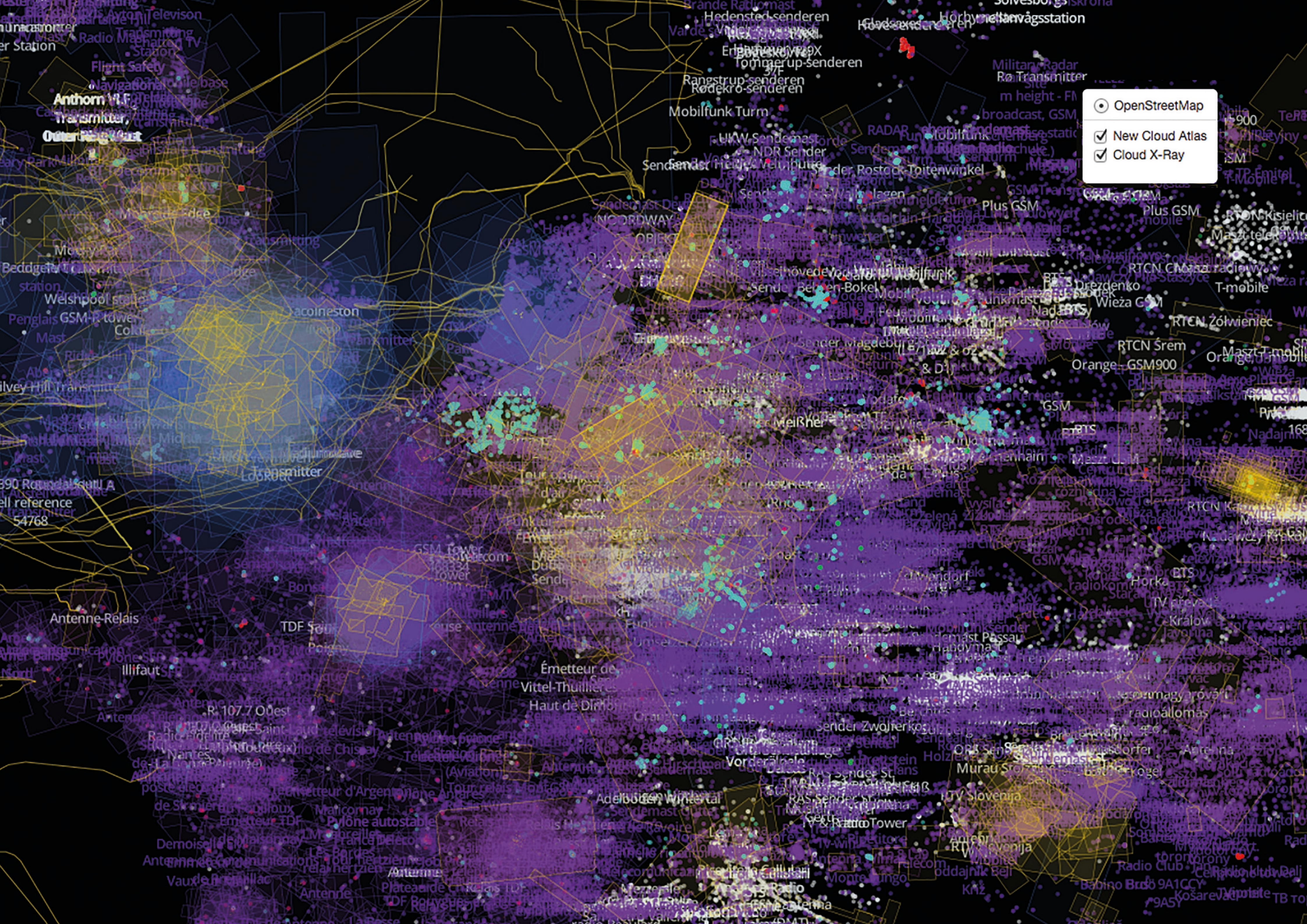
I make sense of my work — as an academic researcher who uses techniques of art and design by thinking of prototypes, projects, performances, workshops and so on — as conducting research through material-discursive conversations. This idea is articulated by Donald Schön, who describes designers as reflective practitioners in conversation with materials, people and situations.

This reflectivity is important because practitioner-researchers should notice their own part in what they do and study. But Barad suggests being reflective is not enough, and we need to take responsibility for the boundaries and exclusions we make. For example, participatory design-research projects can have varying degrees of audience empowerment. A designer can analyse users and talk on their behalf, or consult them briefly, or take more collaborative approaches such as co-design, participatory action research or contestational design.

In my talk at Superposition 005 - *Data, Perception and Music*, I spoke about my design experiments to make space for identity play in networked audiences. For example, in trying to design ways for people to make their own DIY pamphlet zines in the context of the internet, social networks and cloud services, I found that apparatuses of identity authentication quickly enact boundaries in determining who gets to publish and how audiences are made. My prototype design patterns — diffraction patterns of research — take the form of collaborative workshops with multiple audiences, including the entangled non-human agencies of network infrastructures. For example, I've collaborated to make an OpenStreetMap of accountable internet infrastructure; to make empowering zines out of Raspberry Pi kits and Tor network cryptography; and to make other re-distributive carnival spaces of potential networked identity play. Diffraction is more than mere additive interdisciplinarity, as it allows us to co-constitute differences that matter, and to notice quantum effects of time, space and matter. As Barad puts it: *"So this is an example of what I learned from my diffractive engagements with physics: what responsibility entails in our active engagement of sedimenting out the world in certain kinds of ways and not others [… is] that the phenomena are diffracted and temporally and spatially distributed across multiple times and spaces, and that our responsibility to questions of social justice have to be thought about in terms of a different kind of causality. It seems very important to me to be bringing physics to feminism as well as feminism to physics."*

Barad, K. (2007). *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning.* London: Duke University Press. Retrieved from Barad, K., Van der Tuin, I., & Dolphijn, R. (2012). *"Matter feels, converses, suffers, desires, yearns and remembers." In New materialism: Interviews & cartographies* (pp. 48–70). Open Humanities Press.

Schön, D. A. (1983). *The Reflective Practitioner: How Professionals Think in Action (Vol. 5126).* Basic books.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Inclusivity, Continuous Personal Development and the New Economy

Dr. Joanna Leng
& Prof. Wes Sharrock

Intellectual pursuits are commonly elitist. The culture around these activities having developed over thousands of years. An artist is of higher status than a crafter, a scientist is of higher status than a technician and an engineer is of higher status than a mechanic and all are higher status than the general public.

All living organisms need to learn from their environment and adapt if they are to survive. Humans because of their intelligence are very plastic and have adapted to more heterogeneous environments than any other animal and even plan to leave the Earth. There is an innate need to learn and for intellectual and physical stimulation. Intellectual activities tend also to be highly specialised, so much so that nowadays the lack of a public understanding of science is conceived as a social problem, just as there is usually a lack of understanding across the boundaries between specialisms.

The Superposition offers an environment to its members where they can explore intellectual ideas and concepts, join teams and create new aesthetically pleasing items that relate to science. These items in turn communicate concepts and ideas in art, science and making in new ways to the interested lay-person and the general public. Many publics make up the general public, each group of the public has distinct characteristics. The Superposition offers at least two levels of intellectual engagement, one for participants in the group's making activities, the specialists. Many of these people are in the 25 to 60 year old demographic who generally do not get involved in science engagement as their families and careers take up their spare time. The other is for those who view and interact with the group's outputs, often members of the general public who have less interest or less time.

Specialist tools enable specialist results, but specialist tools are usually expensive and beyond the reach of members of The Superposition. The group works by down-scaling, using small and general tools for a variety of purposes as well as re-purposing everyday objects as tools and as materials for their creations.

The human mind responds to analogies which facilitates translating an object or idea into new forms. The group's use of visual analogies such as the use of beach balls in *Unit Cell* not only allows the group to work to a tight budget but encourages the audience to become involved intellectually, drawing on their own experience and analogies. It opens up the creative process and presents combinations of underlying scientific concepts and the arts to the public in new ways.

The bioLeeds sub-group of The Superposition was set up with reference to the DIYbio (Do-It-Yourself Biology) organisation, a voluntary group for those interested in exploring Biotechnology.

This organisation, like The Superposition, is also interested in down-scaling, collaborating and learning but unlike The Superposition one of its main themes is to create designs for cheap laboratory equipment for the developing world.

The original bioLeeds group were introduced at the first ASMbly where they gave talks and then gave workshops on extracting DNA from fruit and making a USB microscope from an inexpensive web camera. The team consisted of Andrew Wilson (an artist), Paul Beales (a biochemist), Lorna Dougan (a biophysicist), Johanna Galloway (a biologist), Paul Turner (a physicist), Joe Corcoran (who ran Leeds Hackspace) and Joanna Leng (a visualizer). The initial projects used local spaces, including a pub and then Huddersfield and Leeds markets to test ideas leading to a contribution to the second ASMbly. The group were involved in a variety of small projects, using only everyday objects from the kitchen, which included: (a) making edible paints (b) creating artworks with them; (c) creating a USB microscope and making microscopic images of people's hair; (d) using chromatography of red fruit and vegetables to make bunting to decorate the markets; (e) making large scale molecular models of DNA and diamond from balloons; and (f) brewing beer.

Over the next years a number of others contributed to bioLeeds and The Superposition, many joining through idea generating sessions. Some of the more interesting outcomes arose from people with very different backgrounds working together. For example Rhiannon Gregory (a material designer) met and worked with Lorna Dougan, Paul Turner and Andrew Wilson on the project 'Textile Proteins' to create novel fabric with a design based on biological molecules that was used to cover 1970s chairs. Bruce Turnbull working with Vicky Ola (an artist and psychologist), Anzir Boodoo (urbanist, artist and puppeteer) and Joanna Leng developed a way for people to make models of sugar molecules out of sweets that were then polymerised, which is a chemical reaction that causes small molecules to form a large molecule, to create a long cellulose molecule. The architect Paola Zanotto (architect) worked with Andrew Wilson, Lars Jeuken (a biophysicist) and Paul Beales, Joanna Leng and Lawrence Molloy (artist and maker) in Archibio to create blueprints of a bacteria cell.

The Superposition was formed and developed as a reaction to the failing of the old manufacturing-based economy and its jobs for life culture. A new economy is forming, a knowledge based one where the individual has to take on ever more responsibility for their continuing training and re-training. The Superposition is strongly connected to other groups involved in new forms of personal and intellectual development such as Leeds Hackspace, MadLab (in Manchester) and DoesLiverpool.

Knowledge resides in people, AI (Artificial Intelligence) and computers process increasingly more data, but it remains people who must understand those results and make decisions. Accessibly disseminating familiarity with fresh ideas and skills from the arts, sciences and technology could potentially improve the transition to the new economy by increasing the number and type of innovative outputs generally available. At this time we do not have a full understanding of what that economy will be, The Superposition and similar groups will continue to form to support active knowledge acquisition through creativity and curiosity.


Table Salt
Methylene Blue (1% Aqueous) 35ml
Harris Haematoxylin (Acidified) 35ml
EDUSCIENCE
150X–900X
Jakar A4

Weaving Proteins

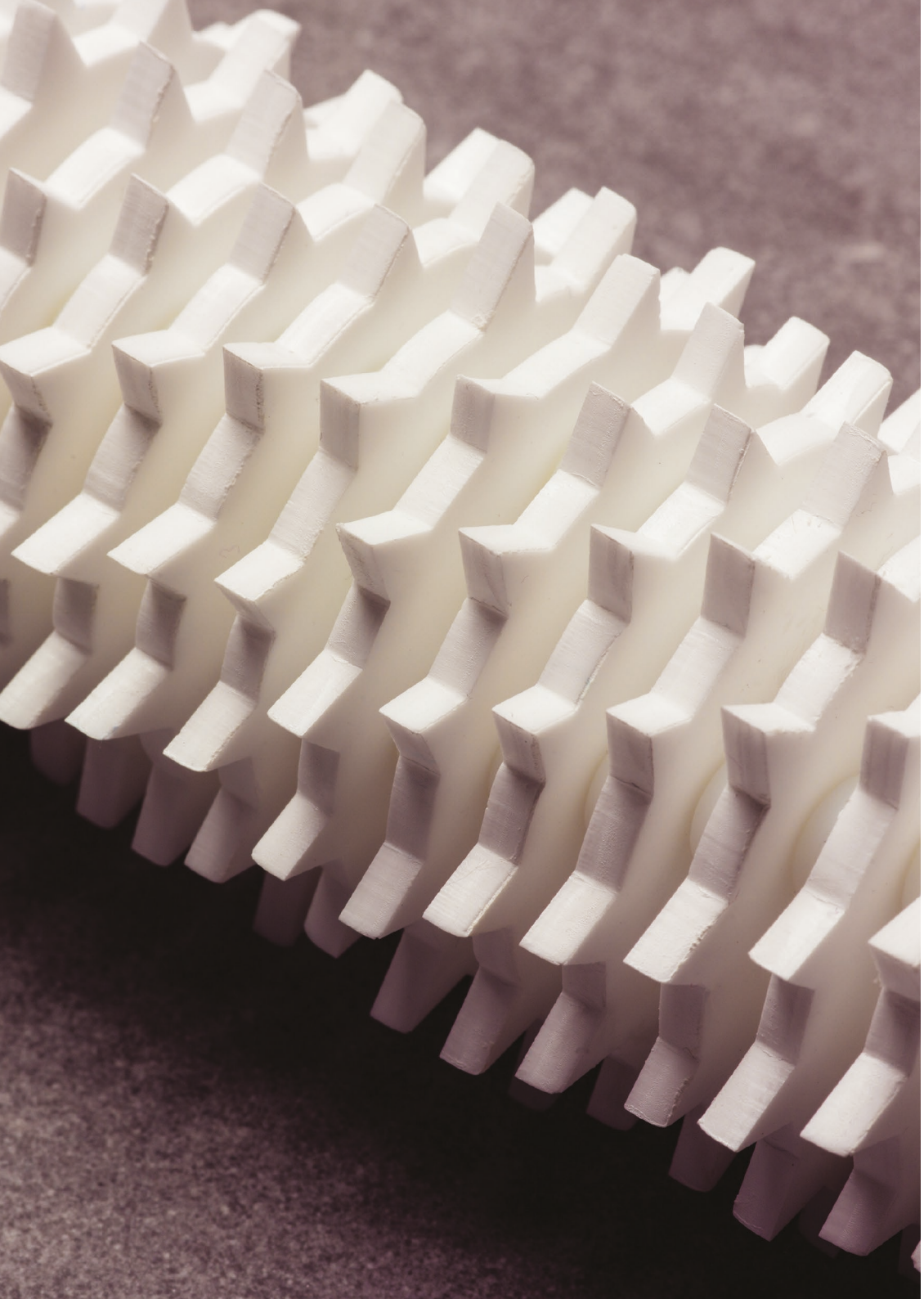
Dr. Lorna Dougan
& Rhiannon Gregory

The Biophysics Design Project is a collaborative initiative to explore the physics of living systems using unconventional approaches. Biophysics or biological physics is an interdisciplinary science that applies the approaches and methods of physics to study biological systems. Biophysics covers all scales of biological organization, from molecular to organs and populations. By using creative design as a tool to investigate the structure, mechanics and interactions of biological building blocks, new representations and understanding of biological systems are uncovered. This approach provides a fresh and alternative viewpoint of otherwise complex biological systems and uncovers surprising scientific insight that would not be possible with conventional approaches. Here we summarise our journey through this process.

The Biophysics Design Project launched in 2017 initiated by Lorna Dougan, Rhiannon Gregory, Paul Turner and Andrew Wilson and was the result of over 4 years of collaboration which began from a BioLeeds sandpit organised by The Superposition. In the beginning we met as artists, scientists and makers to share our common interests and questions. This led to many ideas and possible directions, but importantly key synergies. Although we were geographically spread beyond Leeds city centre we aimed to keep in touch through planned meetings. An important initial focus was the ASMbly Lab in 2015. To date, we have delivered 3 projects (1) Textile proteins, (2) Nanoscale Embroidery and (3) Bio-textiles, and we have plans and funding for future activities.

Textile Proteins

We were interested in experimenting with different rule sets for translating the language used to describe weaving to that of structural descriptions of proteins. Proteins are the workhorses of the cell and are responsible for a vast array of biological functions. They often act as part of a network of larger complex machinery, performing their function through structural and mechanical changes in the biological scaffold.
We were interested to uncover whether the practise of design could challenge us to see proteins in a new way.
During this project, contrasting methods and mathematics behind weaving and textile production with that of protein sequences and how these inform their function, were combined in the search for alternative insights. The first collection of pieces were displayed at ASMbly 2015, alongside a public workshop, where participants were invited to weave their own protein, and learn more about the structures of proteins. The Yorkshire Evening Post featured an article about the event, which attracted participants ranging from young children to grandparents. The project evolved further, and work was displayed at The Astbury Conversation public engagement event in 2016, prior to the lecture led by Nobel Prize Winner Michael Levitt. A pair of chairs upholstered in a digitally printed fabric were exhibited, inspired by the protein myoglobin. The design for this fabric focused on the negative space around the 3D model of the protein, in order to provoke conversation on a new view as opposed to the 'normal' representation of the structure. We



asked, *"Could new information be gathered from considering the structure in this way?"* An interactive 'protein weaving' workshop was also run at the event, whereby participants could learn about the structure of proteins through weaving. The project also received a grant from The Biochemical Society for 'Diversity in Science'. Overall, we were amazed by the diverse range of people we engaged with for this project, from a Nobel Prize winner through to preschool aged children.

Nanoscale Embroidery

The project investigates the potentials of using stitch at a nanoscale level, questioning how this could influence current scientific research into antibiotic resistance. During the project a series of nanoscale threads were developed, specifically designed to stitch onto antimicrobial peptides at a nanoscale – helping them bind to, penetrate and subsequently destroy target bacteria. The perspex models featured in the project demonstrate the structures these threads would have at a nanoscale. Exploring how textile practices could directly influence innovations within scientific research, Nanoscale Embroidery investigates how the role of a designer can directly support scientists in exploration of new approaches to research and testing. The body of work aimed to question the traditionally perceived role of a textile designer, and propose that the designer themselves can have valid input when tackling questions around scientific research and methods. The project won Silver in Fashion & Textiles at the 2016 Creative Conscience Awards.

Bio-Textiles

The development of innovative biomaterials offers enormous potential for addressing significant challenges in medical and healthcare technologies. As life expectancy increases, pioneering methods are needed to replace and restore tissues and organs in the body, to improve tissue engineering and to develop robust and responsive drug delivery approaches. Biological systems provide a challenging template to replicate in biomaterial design. An exciting goal is to push biomaterials towards the complexity of biological processes, to achieve and exceed their level of control. The ability to accurately combine a number of dynamic and bioresponsive mechanisms into biomaterials would lead to unprecedented control of bioresponsiveness and molecular delivery for specific applications.

The first stage of this project was presented at Leeds Light Night 2017, as part of Soapbox Science. A series of e-textiles were created, presenting 3 stages of 'connections' that could be made within one protein. The pieces proved a valid tool in exploring the concept of being able to modify the structure of a protein to have certain capabilities, the 'lights' on each piece showing a developing construction of specific functionality the protein needed to have. The analogy of wound healing was used in order to contextualise the potential of such a construction.
As with Nanoscale embroidery, Bio-Textiles positions the designer within the research process itself, rather than responding to the research in a creative way. The value of using a different outlook, experience or thought process when researching can lead to exciting and unexpected outcomes, and this forms a key value in The Biophysics Design Project.
The e-textile pieces have been exhibited at Otley Science Festival and The Astbury Conversation 2018. *The Biophysics Design Project* presented the next stage of work at Blue Dot Festival 2018, as part of Soapbox Science.

Personal Reflections on ArchiBio (2015-2017) DNA is Not a Blueprint of Life

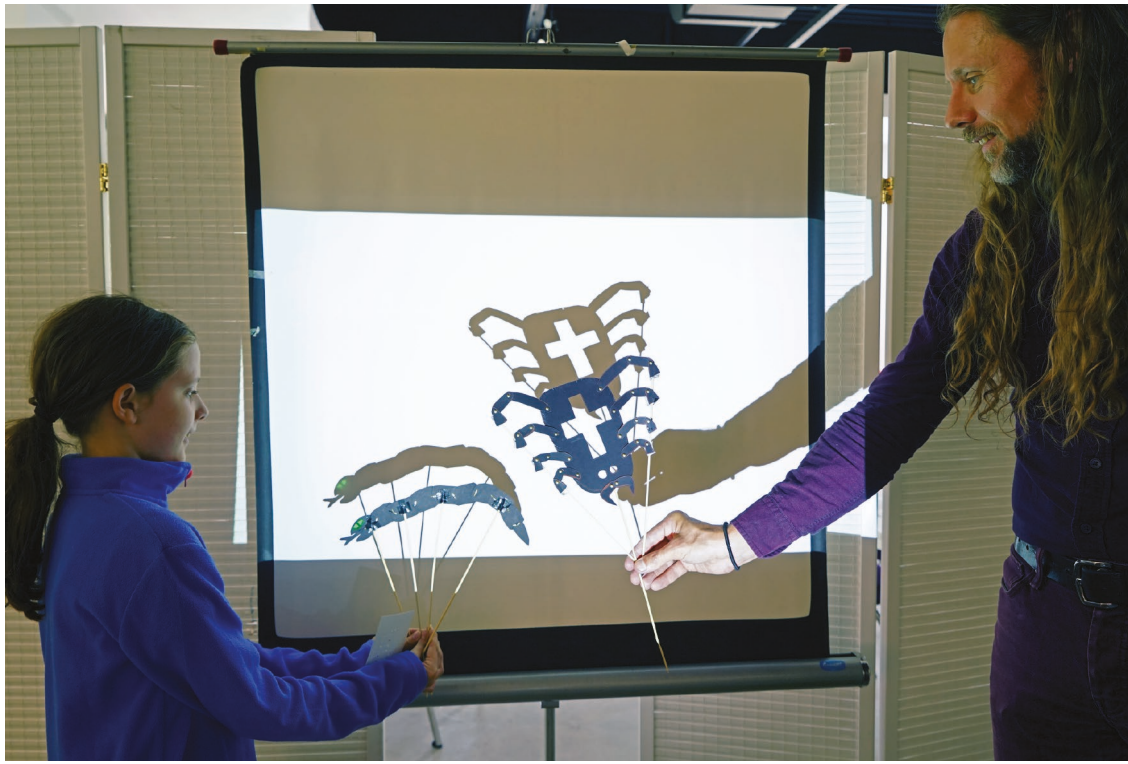
Prof. Lars Jeuken

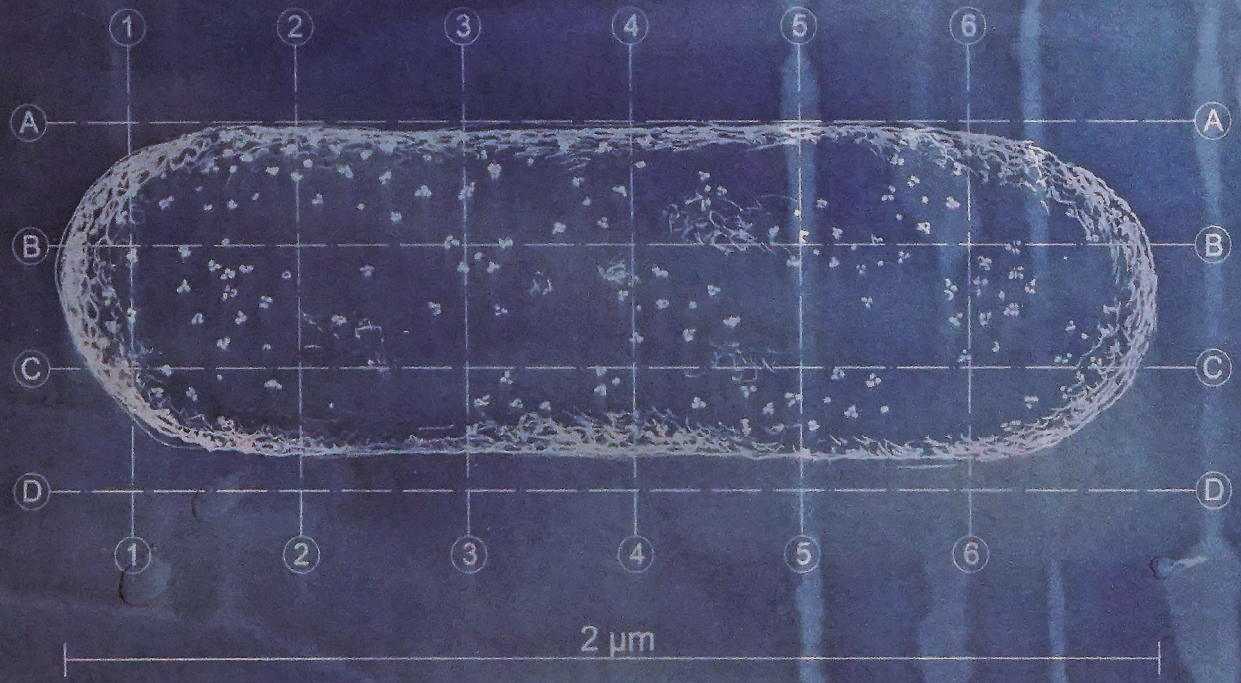
In academic research, like so many other vocations, one is easily stifled with day-to-day management and support, losing track of the creative process that once attracted you to the laboratory. This is where I found myself in 2014, halfway through a very large research programme funded by the European Union. As scientific supervisor I worked full time on other people's problems, and in return scientific research and breakthroughs were lost to me and instead became the playground of those I supervised.

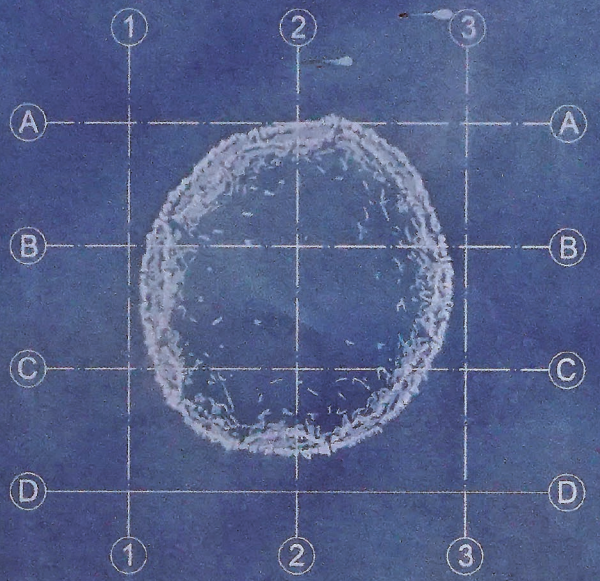
The creativity of solving puzzles, especially if the answers have the ability to surprise you, has drawn me into science. The Superposition and bioLeeds challenged my creativity and original thinking, like the puzzles that once got me hooked into science. In 2015, following the Superposition's recipe of teaming up Makers, Artists and Scientists, we formed ArchiBio. Our Maker was an architect and our vision was to explore biological cellular structures using artistic functionality of architecture.

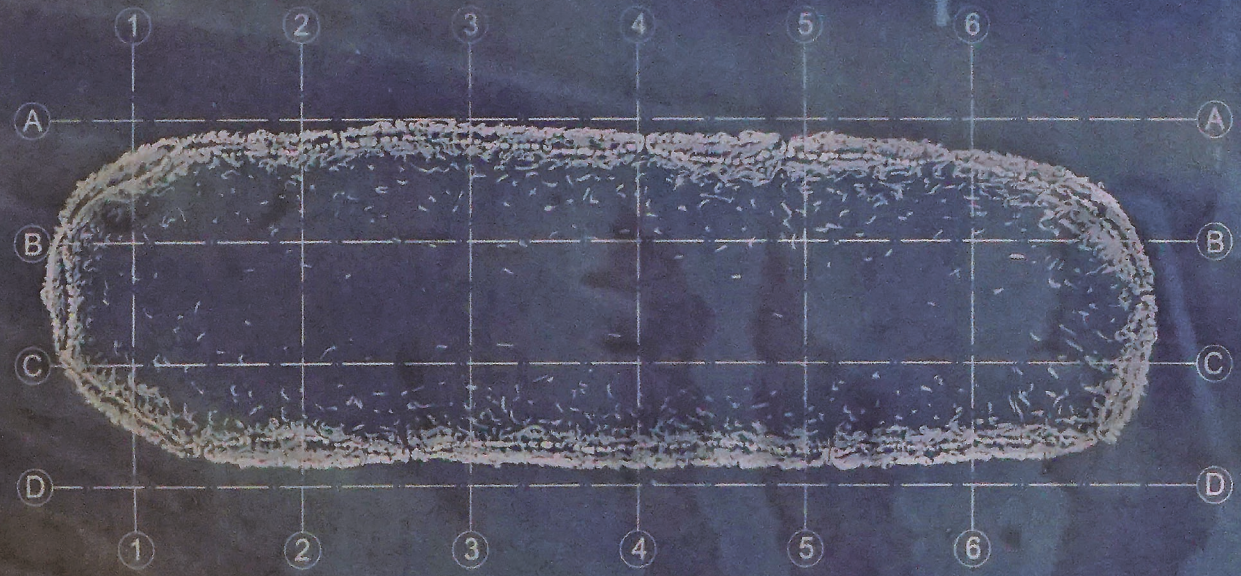
The task at hand was enlightening, but so much more difficult than anticipated. Regular meetings enveloped me in the perspectives of creative architecture: striking edifices with exoskeletons and dynamic living spaces. I was exhilarated by functionality explored in architecture, designing spaces and structures I previously held to be confined to the world of biology. We explored differences and similarities between terminology and created lexicons. We looked at the functional requirements of entry and exit and were amazed how functional living spaces can employ solutions akin to the biological cell.

Architecture, similar to biological science, relies on grasping function and applying knowledge of materials, but creating biological architecture proved too ambitious. The process taught me how little we actually know about the biological cell. Feynman famously said "if I can't build it I don't understand it". Well, we definitely could not design a biological cell, let alone build one. In science we are increasingly able to reverse-engineer biology, but we do this with little understanding. DNA is most certainly not a blueprint of life; blueprints suggests that one understands what is being built.









MATERIALS DESCRIPTION

MEMBRANES:

STRUCTURAL ELEMENTS:

Inner Membrane:

- bending elastic modulus	20 kT
- area compression modulus	0.1 J/m²
- diffusion constant (lipid)	1 µm²/s
- lysis strain	0.05
- resistance	> 1 GΩ/cm²

Outer Membrane:

- bending elastic modulus	100 kT
- area compression modulus	0.1 J/m²
- diffusion constant (lipid)	0.1 µm²/s
- lysis strain	0.05
- molecular weight cut-off	<1 kDa

Cell Wall (Polysaccharide):

- Young's modulus	2 MPa
- molecular weight cut-off	>100 kDa

VERIFY DIMENSIONS OF STRUCTURAL ELEMENTS BEFORE ASSEMBLYING

This drawing has been developed as part of the BioS exhibition

04 Revision 13/07/2

Drawn by
Paola Zanotto

Checked by
Paul Beales
Lars Jeuken

Project
Archibio: a collaboration between artists, architects a
scientists blending architectural and biological structu
from the macro to the nanoscale

scale
A1
5 x 10^{11}

PLAN SECTION AND DETAIL
E. COLI BACTERIUM

Issue

Drawing Number ARCHBIO_17_D_001

ArchiBio Leeds

Paul Beales
Lars Jeuken
Joanna Leng
Andrew Wilson
Paola Zanotto

Herding Collaborative Cats Behind the Scenes

Dave Lynch

Good collaboration smashes specialisms together like colliding waves on water. These collisions create superpositions of rippling inter-disciplinary interference patterns of peaks and troughs which resonate deeply for each collaborator, permanently changing their modes of thinking and approaches. Collective collaboration is a step further with added complexities emanating from multiple waves driven by personal experiences. In this essay I reflect on some of the constructive and deconstructive interferences I have witnessed behind the scenes at labs, events and meetings of a disparate group of people in the North of England held together by The Superposition.

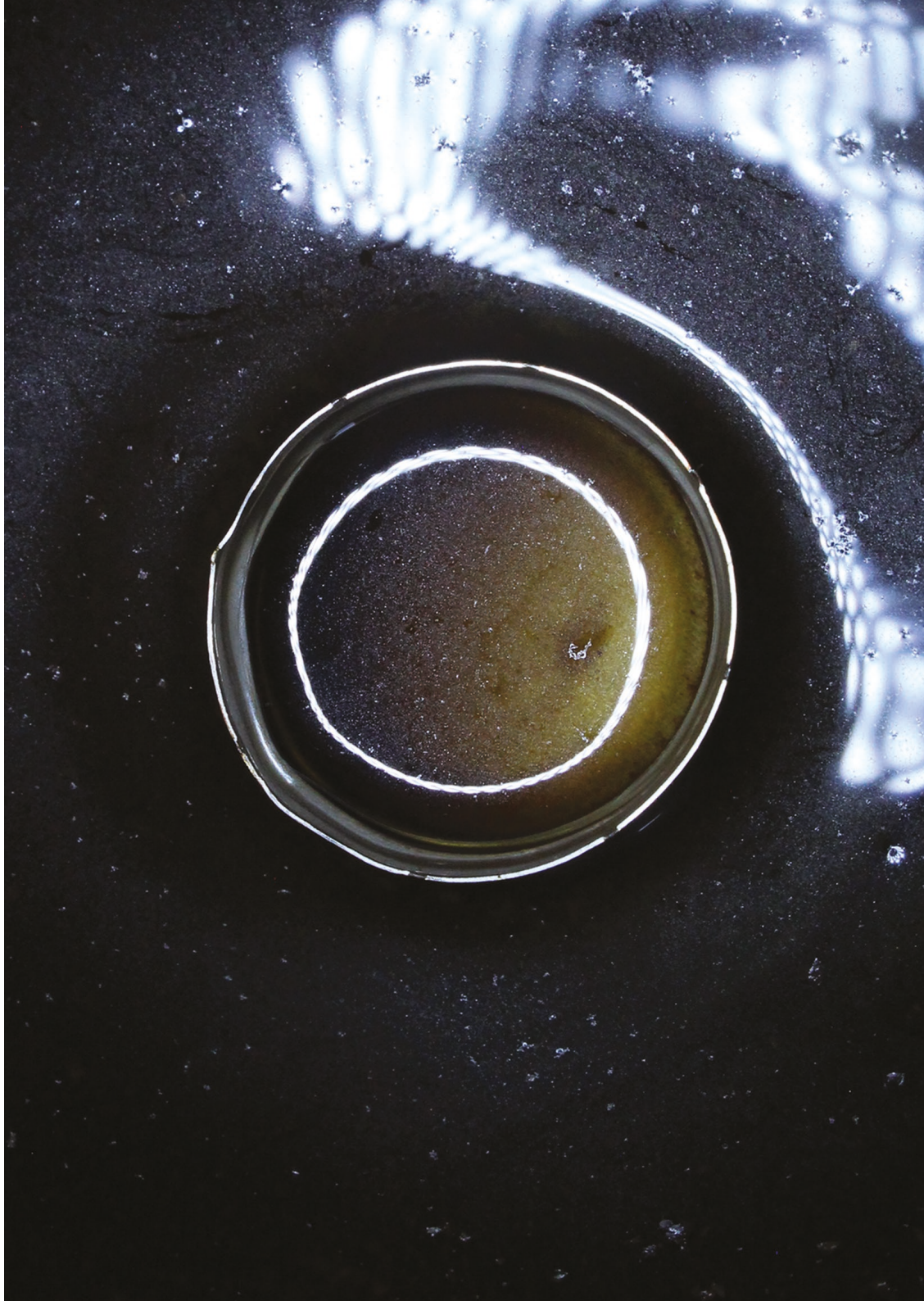
The Superposition is currently a voluntary collective of people who create spaces for collaboration. These spaces can be physical, digital, philosophical and all too often hypothetical. We are organised from the bottom up with fluctuating members taking the lead on different elements. The collective effort that this book is designed to illuminate are co-created, co-opted, co-designed, co-configured, co-failed, co-succeeded and all possibilities in between. All we can share, here in this book, are our current perspectives and reflections accurate at the time of writing on our collaborative processes along with a strong desire to be open and honest about the nature of how we share with the intention of inspiring others. This book captures a moment in The Superposition's evolution through the responses of members who answered an open call asking them to reflect on their involvement and experiences thus far.

De-Constructive Interference – The Troughs

The Superposition's survival has been sustained from the hard work of a small, semi-constant group of individuals sacrificing paid work, pushing friendships to the limit and herding collaboration through multiple social tensions. These tensions know no discipline or status, they simply arise through circumstance and strong personalities working together over time.

The Superposition experiment came into being through fair divisions of labour based upon individuals' skill sets and by harnessing members' excitement, equipment and availability. The work involved in setting up and running a group of this kind has many forms, including administration, planning, web and practical skills and can feel at times like drudgery. Over time members moved on, others joined and more people became interested in the model and the group's activities. This blurred the boundaries between The Superposition as a collective and/or as a network. As the group grows and becomes more disparate how do we manage the increasing amount of administrative work given its varied nature, that some is dull and some requires specialist skills?

After what felt like a year of meetings about meetings about 'how' and 'what' The Superposition does, we developed an 'organisational' swear box to refocus the conversations back onto the 'why'



- to share inspiration and critically explore art, science and making, this in turn gave us dedicated meetings for organisational structures and funding applications. Money and its acquisition has split the group on many occasions. We currently only spend money on actions or things that are for the communal good of The Superposition. We do not directly fund artworks but we may help others do so for example by supporting an artistic commission and associated public call. The mixed sector funding which supported our most successful ASMbly Lab in 2017 and this book created unimagined problems. One founding member departed creating rippling disruptions and heartache, while others laboured more than their fair share.

Constructive Interference – The Peaks

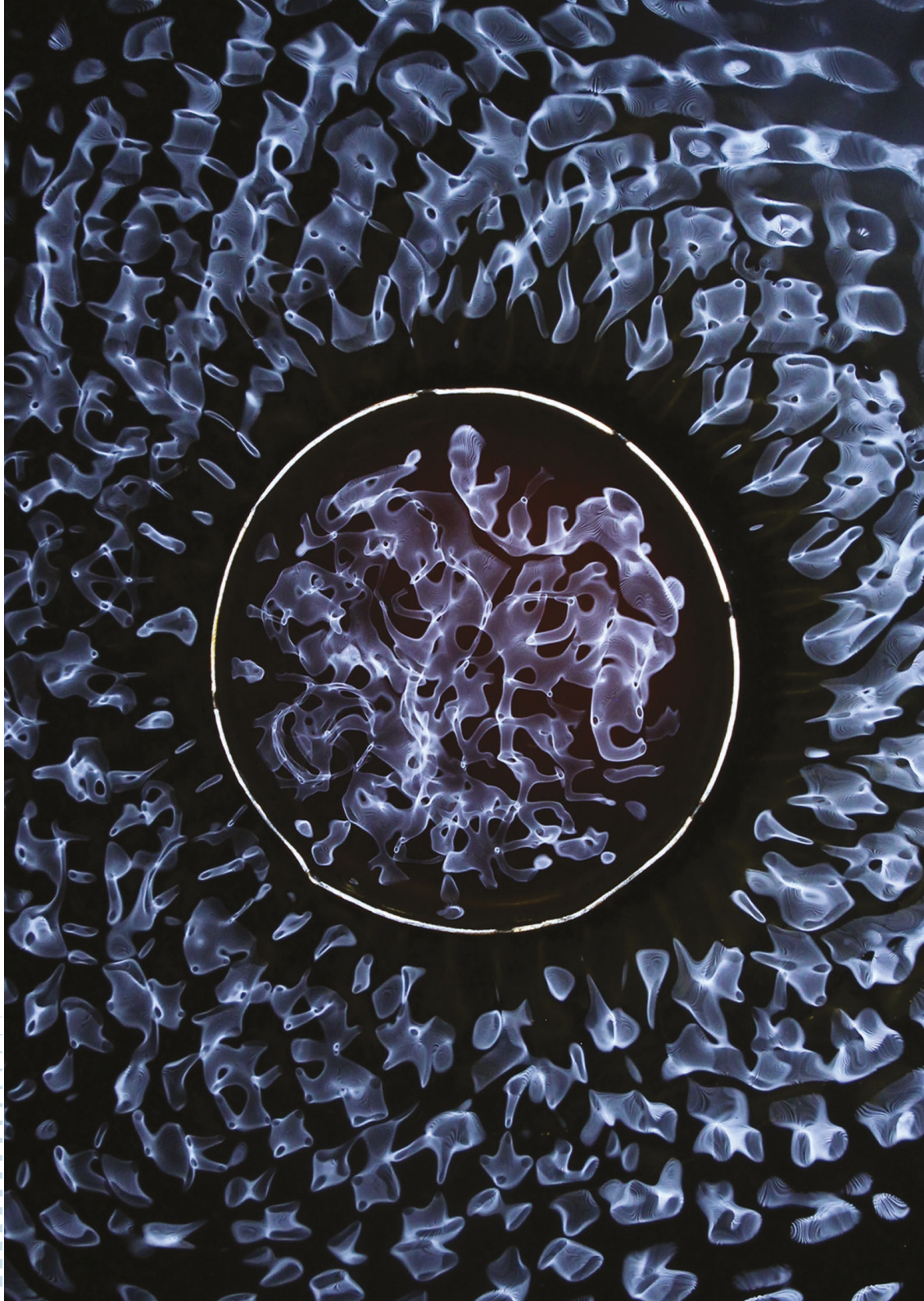
The Superposition was conceived as an experiment to see if we could create a community of artists, academics, scientists, makers, thinkers, tinkerers and doers who share ideas for mutual exploration and collaboration.

Now in 2018, our efforts have become a recognised voice in the cultural dialogue around collaborative practises. The results of the experiment are our collaborative models and transdisciplinary practices and projects that seek to create hybrid forms of art and science. Creative culture celebrates failure, yet, often, value is only attached to the failures of successful projects or people as their novel adventures and discoveries become noteworthy.

A core element of The Superposition, which I believe is a direct function of our collective approach has naturally formulated an environment which nurtures an openness to share experiences on a level playing field regardless of discipline and status. Whether it is at the evenings of talks, ASMbly Labs or pub meet-ups, sharing our failures and haphazard methodologies from across the different disciplines regardless of our other successes is a fundamental part of our collective conscious. It breaks down the boundaries so highlights the nuances of collaboration.

In 2016, we were asked to present alongside other European Art and Science Labs to discuss shared practice and our modes of engagement. Initially we thought the other labs funded by large institutions with salaried administrators, would unknowingly co-opt our models and methodologies and integrate them into their processes and labs. However, we realised our fear was actually our untouchable strength, our loose collective approach gave us flexibility: an agility to be responsive, free from the 'red tape' of time replacement, contracts, reports and tick boxes. Our model, as minimal as it is, enables academics with their disciplinary knowledge to drop in and out; allowing everyone to focus on collaboration in their own time and structure; and enabling synergies with artists to fire their furnaces in an organic, unstructured pursuit of collaboration. Some of the scientists in the collective now incorporate The Superposition's general framework into large scientific funding applications as pathways to impact, to enabling further space and funding for future collaborative projects.

Now in 2018, the collective is in transition, a core group are developing documentation that shares our methodologies online, focusing on the evenings of talks, ASMbly Labs and ideas generation sessions. A new generation of people are in the process of taking control. Only time will tell if our collective can survive and adapt.



ASMbly Lab 2017

Why I argued for the development of an exhibition that included non-members and a free workshop programme

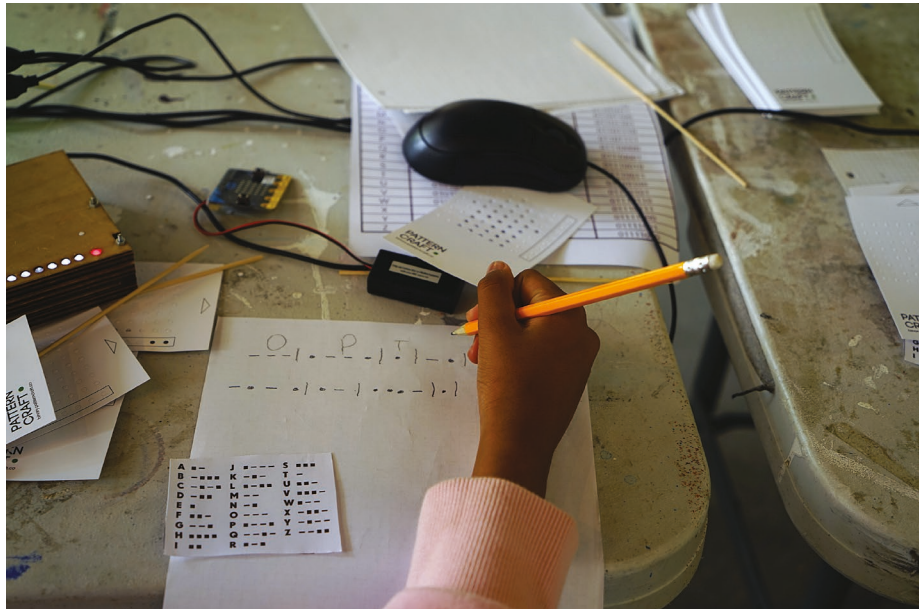
Lawrence Molloy

ASMbly Lab 2017 had five parts to it. The Lab where experiments and art making took place live in the space, a Sci-art exhibition, a series of workshops, an evening superposition event and a closing performance/party. This is a lot of activity to fit into a space in less than two weeks.

The performance had happened at previous ASMblys and had been a really great way for Lab participants who worked either with responsive technologies or that had a live element to show off or test developments they had made during the Lab. For two reasons, it makes sense to do a Superposition evening event at ASMbly, firstly for logistical reasons (we already have a space set up and easy access to equipment), and secondly because the event itself is a draw to audiences who otherwise may not have come to the Lab.
I argued for the development of an exhibition that included non-members and a free workshop programme for the following reasons.

ASMbly 2015 was only a few days long but a big success of that Lab had been the display of curiosities and history of science objects/materials alongside small scale artworks and experiments that had been made by Superposition members in the previous years. I had seen the quality of work being produced in the fringes between art and science both at Ars Electronica Festival 2015 in Austria and that displayed by the University of Hamburg's *Nacht des Wissens* and between art and making when I was resident on the MadLab Manchester's Arts and Technology Accelerator in 2016. Because of these experiences I was keen to produce an exhibition of artworks/experiments that drew from a wider pool than just Superposition members. I wanted to do this for three reasons, firstly I wanted examples of best practice that could inspire Lab participants. Secondly, inviting exhibits was a way to engage those working parallel to Superposition but with whom we as yet did not have a relationship. (This proved an effective way of engaging new Lab and Workshop participants) Thirdly, the Lab was going to be open to the public for a large proportion of the project and having an exhibition gave them something to engage with while also reducing the distractions to Lab participants who were working in the space.

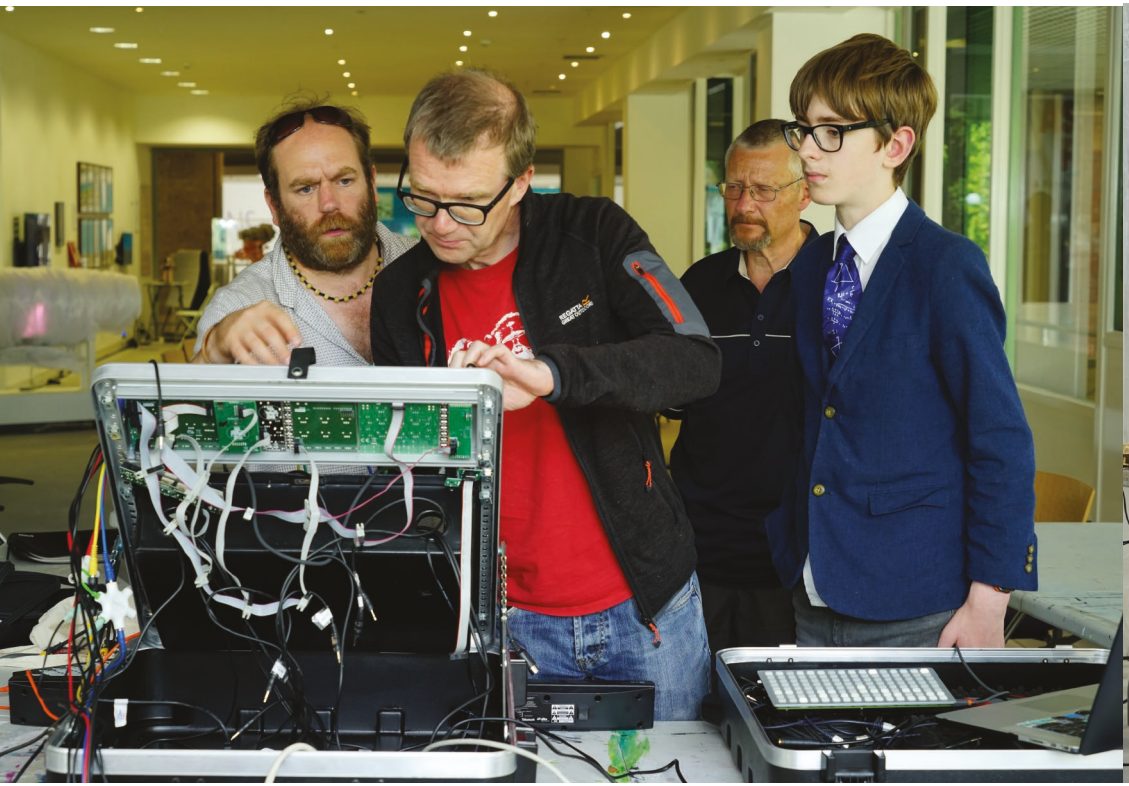
We had previously done workshops on individual evenings or specific days, most memorable to me was the bioASMbly event organised by Andrew Wilson during the first ASMbly Lab in 2013 (this workshop/evening resulted in the founding of bioLeeds) and protein weaving workshops in 2015.



In the past, when presenting Superposition artworks to the public we had realised that while these had been made for fun and creative purposes, they had outreach and educational potential; I felt and argued that whilst being a lot of work, a free workshop programme would complement the lab, provide employment opportunities for members and non-members whilst enabling us to meet this potential.

As an artist who has worked in schools I felt that we should use the Lab to inspire young people and members of the public with the creative potential of science and technology. Importantly, the workshops also provided opportunities for skill learning/professional development of artist/educators/scientists who were or were not participating on the Lab. Many workshop leaders also ended up participating on the Lab and this led to a number of new and exciting collaborations.


ASMBLY LAB
FESTIVAL




Morrisons
MARKET ST


ASMBLY LAB
FESTIVAL
A Family Friendly Art, Science, Maker Lab.
THE
SUPERPOSITION
ART, SCIENCE & MAKER TALKS & DISCUSSION
Humans, Puppets and Robots: What's the difference? #asmblylab
THE
SUPERPOSITION
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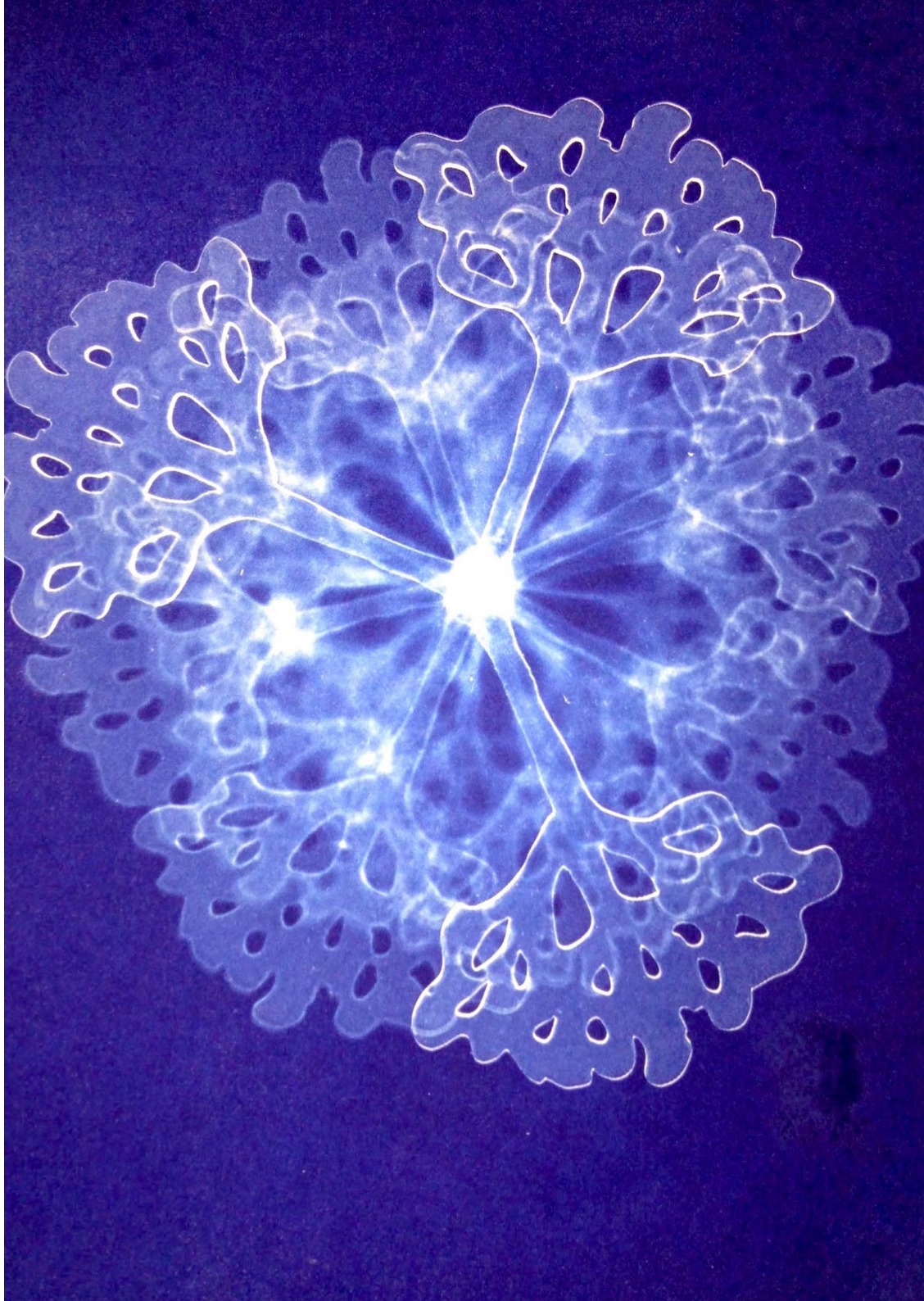


Humans, Puppets and Robots: What's the Difference?

Anzir Boodoo

The Superposition's Evenings of Talks are fora for discussions around a particular topic from the perspectives of an Artist, a Scientist and a Maker. They happen up to four times a year, and are intended to foster the cross-fertilisation of ideas between these three perspectives, recognising our awareness of the overlaps and how many of our own practices straddle the boundaries between all three.

Putting the evenings on traditionally started by seeking three speakers, one from each perspective, and has gradually changed from organising around particular speakers to organising around a theme, then seeking speakers we know, as well as those we are unfamiliar with, who make exciting work from each of the three perspectives. This allows each of the speakers to play to their strengths and showcase their work. However, for the event at the 2017 ASMbly Lab, I started by offering a provocation to the Artist, Scientist and Maker relating to my own interests in puppetry, robotics, and the movements of the human body - *"Humans, Puppets and Robots: What's the Difference?"*. Being both the Artist of the triad and the organiser wasn't ideal in that it skewed the balance between the perspectives, but on the other hand it allowed me to explore the provocation more deeply with the Scientist and Maker. Fittingly for The Superposition and its aims, none of us fitted squarely into the Artist, Scientist or Maker boxes, but came with our backgrounds in Neurobiology, particularly the brain's control of the hand (Samit Chakrabarty as Scientist), Robotics, mainly in disability rehabilitation (Raymond Holt as Maker) and myself as a Puppeteer being the Artist. Making the interconnections between our practices the focus forced us to work on how to bring our perspectives together, as opposed to the introspective approach of focusing on our individual work and what makes it distinctive.

Starting with a provocation to the three of us, as opposed to a theme, led us to discuss how we could respond collectively, and it being something I was interested in for my own practice meant I was engaged in exploring the possibilities that the other two speakers could offer more deeply than if we were just organising one of our usual series of talks. The process of putting on the evening therefore became a research project in its own right.

We met for an exciting conversation about how we could bring together our practices and research areas, and discuss the roles of robots and puppets in rehabilitation, animatronics as a bridge between puppetry and

robotics and the complexity of replicating in robots the degrees of freedom of movement in the human hand.

The other two speakers were quite excited about the provocation, and, as good as the evening turned out to be (at least from the feedback we got afterwards), what didn't end up happening on the night was probably at least as fascinating as what did. Other possibilities we had discussed before the evening included building a demonstration robot to show the similarities and differences between movement making for humans and robots, and demonstrating how Trans-cranial Magnetic Stimulation could be used to turn a human into a puppet by firing electromagnetic pulses at their motor cortex.

Our approach resulted in three inter-connected talks. Raymond defined robots as artificial objects which perform physical actions based on what they sense (not necessarily using Artificial Intelligence) to adapt their choices based on success and failure, as most robots simply follow an algorithm set by a human programmer, which he described as a form of time-delayed puppetry. I then introduced puppets as conveyors of movement and expression to an audience, which could function as a prosthetic by extending the puppeteer's abilities, and that 'robots' which function only by remote control, such as those in *Robot Wars,* can more accurately be described as puppets. Samit then compared how the brain controls the human body through feedback loops with the control of robotic movement, and demonstrated how we can interrupt our perception of muscle position by using only an electric toothbrush. The question he posed here was whether humans are, at least consciously, as in control of their movements as they think.

This organisational process opened up new possibilities for The Superposition, by creating new collaborations between Artists, Scientists and Makers who would not otherwise work together, and allowing us to see the possibilities of our work from different perspectives. This also creates the potential for a Superposition evening to be the start of a collaborative process between the Artist, Scientist and Maker, rather than an end point of each talking about work that has already been made.

Ghost Sculptures:
Serendipity and the Importance of Conversations With No Aim!

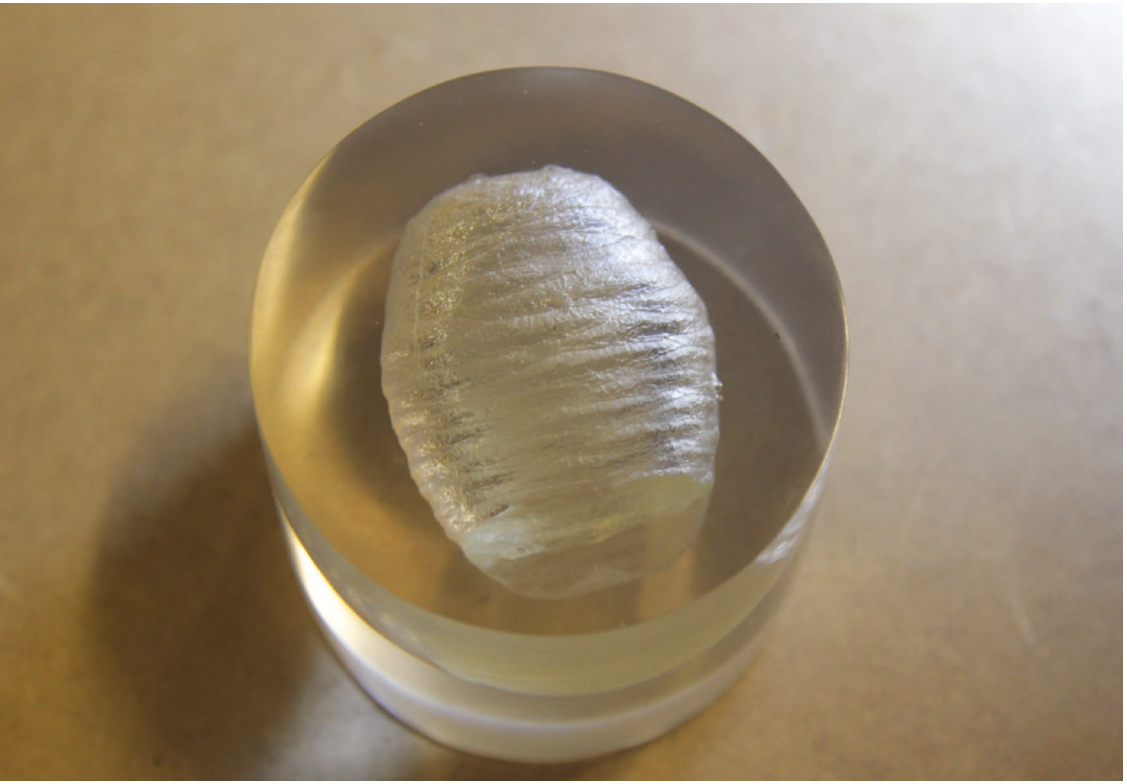
Lawrence Molloy

The painter Chuck Close said, *"Inspiration is for amateurs."* This means not waiting for inspiration, but rather engaging in processes and actions from which interesting things can arise. As a collaborative art maker, I believe it is important to be open to opportunities and conversations that initially have nothing to do with your work or ambitions. I also believe that reading and engaging in research outside of my field makes me a more rounded person and better artist. Superposition exposes me to conversations that are varied and often nothing to do with art; however, these often lead to interesting and unexpected projects and collaborations. Indeed, co-founding The Superposition with Dave Lynch, Mike Nix, Prof. Ben Whitaker and Andrew Wilson was one such project/collaboration that resulted from independent research, conversations and being loosely involved/helping-out/fabricating on a number of science and technology related projects over a number of years.

The implied action in the saying "Inspiration is for amateurs" gives a clue to another truism, that involvement in opportunities creates opportunities. An example of this would be *Ghost Sculptures. Ghost Sculptures* reveal the beauty of natural and social history objects by stripping away their weight, colour and substance leaving only a glimmering form to contemplate and explore. They're hidden within clear shapes, such as cylinders and cuboids, which when illuminated cause objects made of light to magically appear within. For the purposes of this piece what they are is less important than how they work and how they came to be.

I had been working as Artist in Residence at the Museum of the History of Science, Technology and Medicine (HSTM) at the University of Leeds since mid 2012 to develop games, artworks and engagement strategies that created a more visceral/haptic engagement with the material culture related to HSTM. This residency had resulted from of an introduction to the Museum's director Claire Jones, by the curator of the Stanley & Audrey Burton Gallery who knew of the artworks I had made with/for educational institutions and the work I had been doing with The Superposition. In 2013 I was asked to work with them to create artworks for Light Night that celebrated the centenary of William and Lawrence Bragg winning the Nobel Prize for "their services in the analysis of crystal structure by means of X-rays"

There had been a number of events to celebrate the centenary including a Café Scientifique lecture by Chris Hammond that I had attended months earlier. At this lecture he explained what diffraction is and how the diffraction patterns of X-rays produced a pattern on a flat plate from which, using a mathematical formula devised by the



Braggs, the molecular structure of solid materials could be worked out/inferred. He explained that this technique continues to have a lasting impact on scientific research into the development of new materials and its importance to Crick and Watson's discovery of the molecular structure of DNA.

The idea that modern scientific experiments happen at physical and temporal scales that are too small to be directly observed and so results have to be inferred was one I first encountered in the writings of Nobel Quantum Physicist Richard Feynman. It had also often come up when talking to Superposition members Dr Mike Nix and Prof. Ben Whitaker about their research as they are interested in the femtoscale. Indeed, days before The Museum of HSTM asked me to make the artworks for Light Night, Mike and I had been sitting in a Pub discussing unexpectedly complex and beautiful results he had experienced in the Lab earlier that day. Over quite a few beers he was excitingly telling me that he had run a test on what he had expected to be a boring experiment, and that on paper it looked like it was going to be a simple transfer of an atom between two molecules. The result of the reaction was indeed a simple transfer of an atom between molecules, however it was not a direct transfer. Rather, for this to take place involved a highly and unexpectedly complex chain that no one could have predicted. His discovery of this complexity had Mike quite excited and while I could not follow the physics or maths, the description of this complex molecular ballet was almost poetic.

Therefore, when asked to make artworks for Light Night I knew I wanted to make artworks that explored the idea of indirect observation/inference. Light Night was scheduled for October and as luck would have it we had already decided to do the first ASMbly Lab in September. Mike and I used the lab to develop a technique for dissolving metal salts into water clear resins. Doing this increased the density of the resin, which in turn increased the refractive index of the material meaning that light would travel through altered and unaltered resins at different speeds. It is these in differences refractive indices that make encapsulated clear objects appear when the ghost sculptures were placed under strong light.

During the Lab, Mike and I had worked mostly with jelly molds and plastic cups to make shapes for our proof of concept prototypes. Because of the link between X-ray diffraction and the discovery of the structure of DNA, and because I had access to specimens through the Museum of HSTM it seemed appropriate that the subject matter inside the *Ghost Sculptures* should be natural history objects. After ASMbly I made moulds of bones, seeds, insects and plants that I could later cast with our altered resin. Dominic Hopkinson, a trained stone carver/sculptor and Superposition member, worked with me to refine the encapsulation and polishing process of the ghost sculptures to ensure that these beautiful objects were finished in time for Light Night.

So to summarise, my meandering tale of the *Ghost Sculptures* is not one of luck or aimless happenstance. I tell it to try to demonstrate that being actively involved in communities, conversations, skill swaps and the world around you creates serendipitous circumstance from which interesting things can and will come.

Artistic-Led Concept Experiments Were Key to the Art, Science and Making of 'In Transition'

Cat Scott

"I can't understand why people are frightened of new ideas. I'm frightened of the old ones."
(John Cage in *Conversing with Cage*, page 221, 2003)

The work and practices of John Cage have inspired and influenced my artistic practice since before I started working with artists, scientists and makers from The Superposition collective. Conceptual art and improvisation are key to my work. They are an inherent part of the artistic, scientific and making processes and are the core of experimentation itself.

"Conceptual art is based on the notion that the essence of art is an idea, or concept, and may exist distinct from and in the absence of an object as its representation."
(Guggenheim Collection Online, 2018)

"The term 'fine art' was used to differentiate works by artists who were the sole agent of creative expression from works that were created by commission, or objects with utilitarian functions that fall into the category of craft or decorative art." (What is Fine Art? Canvas - blog by Saatchi Art, Evangelyn Delacare, 17/11/2016)

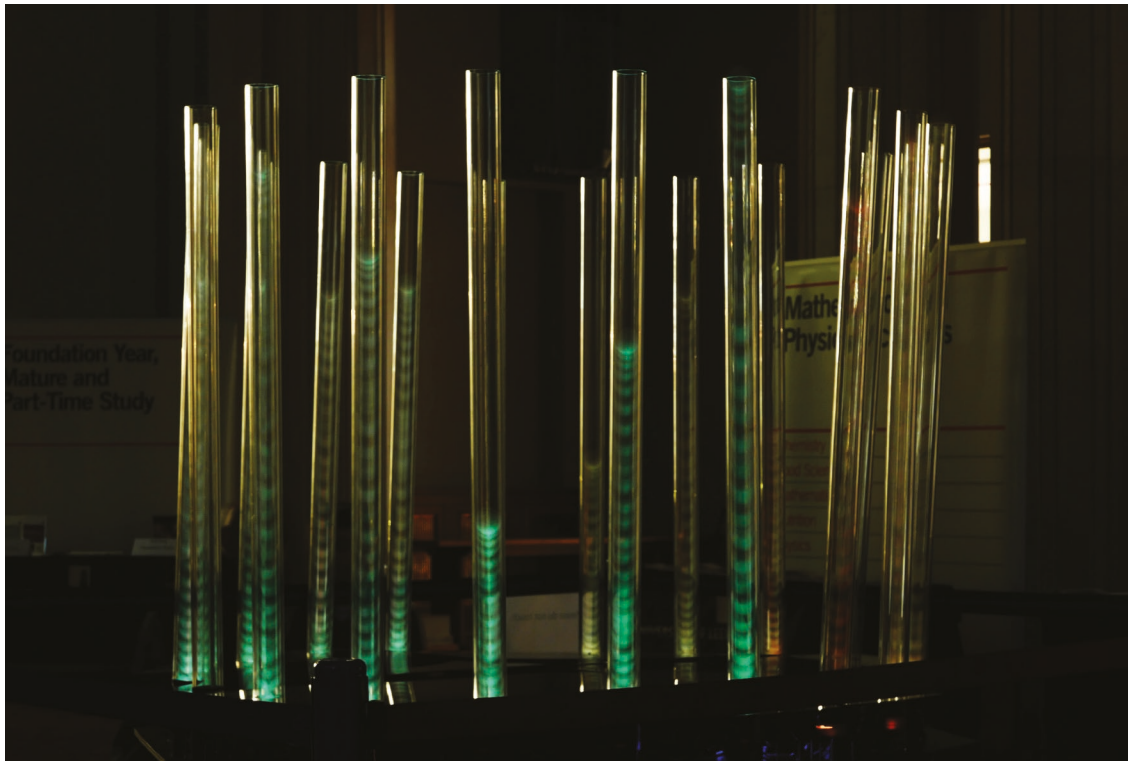
"The avant-garde movement prioritised concept and intellectual purpose over aesthetics. Modern works such as 'The Fountain' by Marcel Duchamp and 'Starry Night' by Vincent van Gogh are in accordance with the definition of fine art as they express the true intentions of the artists without restriction placed by a patron." (What is Fine Art? Canvas - blog by Saatchi Art, Evangelyn Delacare, 17/11/2016)

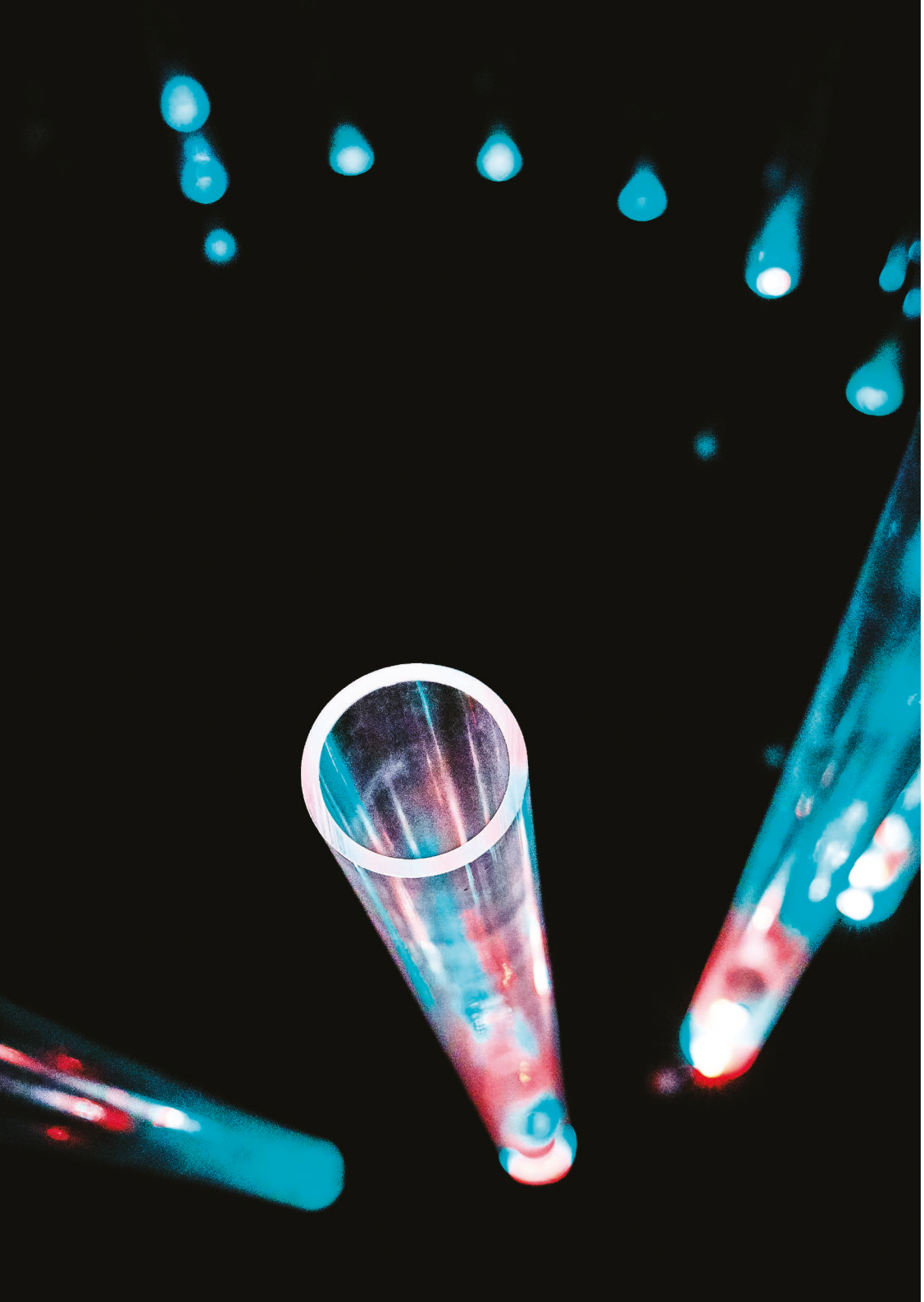
What is an experiment?

Artistic-led experiments are led by intuition and curiosity. To me, the process of experimentation is creating something led by my 'child-like' sense of curiosity, where I ask questions and my intuition guides me through the decision-making process. An experiment also allows me to explore an idea without the restrictions of having an end point or function, or in other words using 'blue sky thinking' (thinking without restriction). The process of creating artistic-led experiments are a personal journey, with little or no context in mind, during the creation of a work. Whereas the scientific method takes a theory and turns that into a hypothesis (an explanation of a phenomenon that can be tested where each test has a yes or no answer) and an experiment is a reproducible series of tests that are measured and recorded. Furthermore, an experiment in artistic terms is led by improvisation, in contrast to the 'scientific method' which is led by discovering facts about the physical world. Overall, experiments in both art and science are there to either prove facts or to learn something new.

I am a philosophical thinker who uses 'blue-sky thinking' for experimentation in the early stages of a project, where the concept for the artwork has not yet been decided. Improvisation and blue-sky thinking are at the heart of my experimentation, providing me with free-space to think without restriction.

It is the role of the project leader to determine the dynamics of the experiments. I strongly feel that the conceptual element deepened the work In Transition. For example the Composer and Sound Artist





John Cage created a series of conceptually-led experiments with everyday sounds that he believes to be 'music'. His artistic-experimental approach in his most famous experiment '4'33"' (where he stands in front of an audience to compose in silence without an orchestra) Cage demonstrates how the white noise in our everyday environments is music in its own right. This is a key example of the difference between artistic-led and scientific-led experiments. Cage has evolved our understanding of what 'music' is today and has made us look at the world as if all sound is music. Cage was a radical thinker, who saw the opportunity to experiment with the boundaries of the classical music community, in order to create new ways of thinking and responding to the world around us. Similar to Cage, throughout this collaboration we explored the common elements in our approaches to improvisation across all disciplines. We were investigating elements of play and how it leads to creativity. This expanded our options for ideas, materials and the artwork we created. For example, using gravity and anti-gravity as a sound source meant 'In Transition' emitted a sound that piqued the interest of Azlee who is a sound artist. The sound was completely a by-product of our initial research, but became an important element of the final work. Without our improvisational approach, sound may not have featured as prominently. An integral part of this project was devising the artistic-led concept experiments inspired by Diego's research on physical phenomena, such as: the energy quantisation of atoms and gravitational waves, state superposition, the laws of gravity and wave-particle duality to create a kinetic sculpture. These experiments included:

- Hacking strobe lights to explore a way to embody the concept of 'the superposition' of atoms and resulted in them 'jumping' up and down tubes. Mark and Anzir developed software and bespoke electronics. They built a system to power the fans and strobe lights in sync with one another, to produce an accurate levitating sine wave.
- Exploring aerodynamics, by using a variety of 'found' spherical objects. By using various fan speeds with a selection of tubes and balls, we were able to research how airflow works in different 'spaces', to ensure the balls defied gravity in the style of a sine wave.
- Exploring the sine wave further, using a signal generator and a mixing desk to play around with frequencies and using the application Pure Data to create an animation of the sine wave from the sound.

My work on 'In Transition' has strengthened my admiration for John Cage. His radical approach proves the importance of noticing the way in which we think about the world and how this heavily influences the things we create. I will continue to develop the processes of artistic-led concept experiments and use conceptual and experimental art, to inspire my artistic practice and to deepen my collaborations with artists, scientists and makers.

John Cage in *Conversing with Cage. Richard Kostelanetz, John Cage and The John Cage Trust*. Second Edition (2003). Esthetics, chapter 11, page 221. Routledge, New York and London. Retrieved on 30/08/2018 from goo.gl/sHpDi4.

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What is Fine Art? Canvas - blog by Saatchi *Art, Art History 101*. Evangelyn Delacare (17/11/2016). Retrieved on 30/08/2018 from https://canvas.saatchiart.com/art/art-history-101/what-is-fine-art.

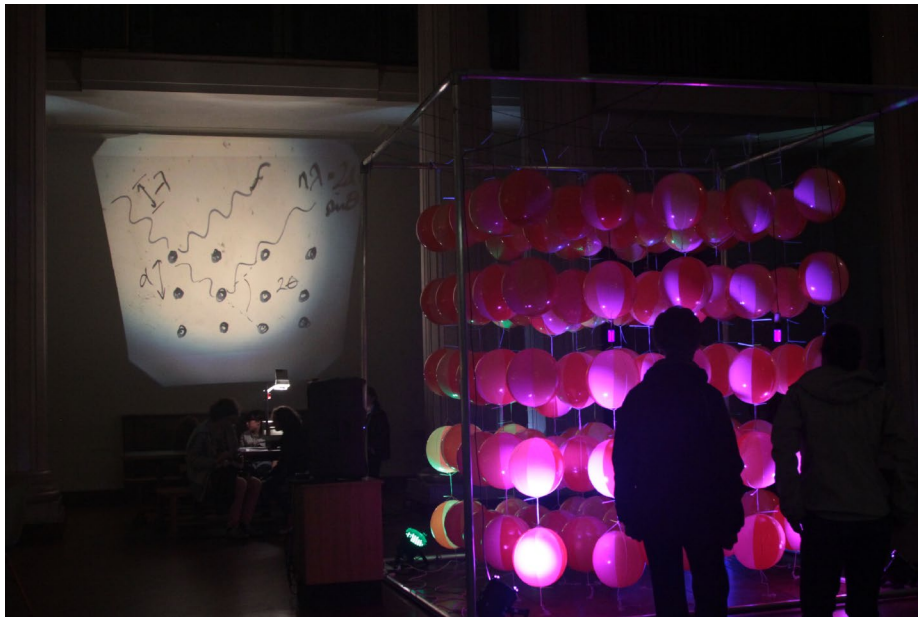
Unit Cell: Turning Experiments into Experiences

Dominic Hopkinson
Lawrence Molloy
Prof. Ben Whitaker

The idea for *Unit Cell* grew out of the first ASMbly Lab in September 2013 about the time the University of Leeds was organizing a series of events to commemorate the work of William and Lawrence Bragg. The Braggs (father and son) were awarded the 1915 Nobel Prize for Physics for their work, in 1913, developing X-ray crystallography by which the atomistic structure of materials from rock salt to proteins is now regularly determined. In *Unit Cell,* sound is scattered analogously to X-rays in a crystal lattice. The sculpture is a suspended array of 125 beach balls in a cubic lattice, each ball representing an individual atom. Sound, which represents the X-rays, is directed into this lattice, bouncing around before being scattered out of the lattice. As the sound waves emerge from the sculpture the scattered waves interfere; either cancelling each other out to make a zone of silence, or adding together to make a zone of noise, which the audience experience as they move around the piece. The effect of the sound around the sculpture acts at a distance of tens of metres and is fully three dimensional as a sound field. Audience members experience these different loud and quiet zones as they move around the work. These sound zones are also being scattered at an angle to the midline of the cubic lattice, and so are experienced at different heights.
A child stood next to a 6 foot tall adult will hear the sound in a different place to the adult, and so the audience are able to move both laterally and vertically through the soundscape.

The first iteration of *Unit Cell* was made during the first ASMbly Lab in 2013. Dr Mike Nix and Prof. Ben Whitaker (with help from other lab participants and volunteers) created a rudimentary structure that utilised the ceiling tile suspension grid already in the space, 2x2 lengths of wood and string to suspend beach balls. Amazingly this construction diffracted sound creating a pattern that could be explored by an audience. Unfortunately it wasn't particularly pleasant to look at, and this DIY aesthetic detracted from the elegance of what this lattice of beach balls was doing.

We managed to sneak the piece into the 2013 Light Night by gatecrashing Lawrence Molloy's *Invisible Sculpture* show. Before Unit Cell could be shown to the wider public, it was felt that a redesign was in order. To this end, Ben and Mike started to work more closely with Dominic Hopkinson and Lawrence Molloy to improve the levelling of the beach balls and create a cleaner look that would enhance the experience for the Light Night audience. The wood structure was replaced with scaffold tubes, and the strings replaced with monofilament fishing line. The whole structure looked more considered and the beach balls appeared to float in mid air since the fishing line was almost



invisible, especially when the piece was lit at night.

On Light Night 2013 *Unit Cell* was shown in Parkinson Court at The University of Leeds. As a result, it was seen by Dr. Arwen Pearson, one of the organizers of the Bragg Centenary Lecture to be given by Daniel Shechtman (2011 Chemistry Nobel Laureate) and *Unit Cell* was consequently commissioned for an exhibition to precede the lecture. Shechtman had received the Nobel Prize for his work on quasicrystals, which are aperiodic lattices analogous to Penrose Tiles. By the serendipity that is Superposition, Penrose Tiles and an exploration of the possibility of a three-dimensional analogue had been the subject of Dominic Hopkinson's contribution to the first Superposition Artist-Scientist-Maker symposium the previous year. The members of the build team were invited to attend Schectman's lecture and hear, first hand, the serendipitous confluence of his ideas and research as it related directly to the theories behind *Unit Cell*.

Shortly after this, Dr. Pearson left The University of Leeds to take up a major role at DESY, the German Electron Synchrotron facility based at University of Hamburg. Her team, the Pearson Group, based in the Centre for Ultrafast Imaging at DESY, focuses on understanding how macromolecular structure leads to function; how large molecules are not static and thus need to be understood both spatially and temporally. Upon her arrival Dr. Pearson contacted Superposition and commissioned *Unit Cell* for DESY, built and installed on campus for the Nacht des Wissens (Night of Knowledge) an event similar to Leeds Light Night, but held every two years for public access to the University.

Lawrence, Dominic and later on Ben, went to Hamburg and rebuilt *Unit Cell*. Over the course of a week we refined the process using much better quality materials.

At DESY, *Unit Cell* was sited outside, so we were able to test how far the effect travelled, and discovered that it was effective at least 300 metres away! This gave audiences and us a lot of space within which to explore the soundscape that the sculpture's structure created. People explored it in many different ways; some rode bikes round it, others ran towards and away from it (this created a Doppler effect of sorts). There was also ducking, jumping, dancing, arguing (usually between parents and children) and one deaf family used balloons to feel the sound vibrations. Once audience members had experienced the sound diffraction, many wanted to know more about how it worked, the theory behind it and how that related to the research being done at DESY. So, in between playing, with the help of Arwen and her team, we spent 12 hours discussing the work with the German public (in very bad German on our part, and embarrassingly good English on theirs) and how these ideas related to research being done at DESY.

With predictable German efficiency the work was then craned over the building it was displayed outside of, and sited "permanently" in an inner courtyard. However, after about a year it was badly damaged during a storm, after which we assumed it would not be rebuilt. We were wrong and the latest iteration of *Unit Cell*, built with longer lasting and more robust materials rose from the tatters, and is still at DESY, Hamburg.


CFEL
Center for Free-Electron Laser Science

Glossary of terms

This glossary of terms was produced by asking the contributors of this book to respond to specific words and phrases. It's purpose is by no means to be a collection of definitions. They are statements accurate to the perspective of the writer at the time of submission and informed by the intentions behind their essays and experiences. The aim is to show the fluidity of meaning, how disciplinary terms and language evolve through playful interaction, dialogue and shared experiences.

Art

A: Not necessarily a carrot, but could be. Possibly more cerebral than a cauliflower, but then again… maybe not.
OR
1. A life affirming activity/form of play that combines physical action/skill with concept to create an object/event/experience in any medium and whose creation is framed by the creator's ideology and response to the dominant mode of production at the time of making.
2. Reaching for the sublime and the profound. Good art functions on a higher level than to illustrate what it is 'about'.
S: Physical representation of a concept or idea. Literal or abstract reproduction of nature or one of its aspects. A means for the artist to transmit an idea or to evoke an emotion in the audience.
M: A sensory and technical experience

Science

A: A fun, uncertain and often methodical means of exploring the universe whose starting point is the acceptance that many of our assumptions may be wrong.
S: The human activity of generating knowledge for the description and understanding of the natural world by following rigours, though diverse, methodologies.
M: The study of natural phenomena through a process of experimentation that strives to produce ever increasingly accurate models of reality.

Make

A: Action
S: This is called "experiment".
M: Making is concrete thinking. It isn't any old playing around, it's playing as a form of material conversation. It's ready-to-hand and bricolage, in search of creative leaps. Critical makers are right to question the fetishisation of nostalgia found in some corners of maker magazines, labs and faires, and to recognise that outside of privileged contexts, people are making all the time, not just as a hobby or aesthetic.

Process

A: A means of investigation where the outcome is determined by material and conceptual exploration.
S: Action applied to a physical system to drive its evolution from an initial to a final state.
M: A defined period of time when cause and effect contingencies are enacted towards more or less determined outcomes.

Play

A: 1. Exploration without boundaries driven by an open curiosity for all stimuli to share equal value.
2. See Pat Kane's ***theplayethic.com***
S: This is called "experiment".
M: To engage, experiment and have fun with other people.

Experience

A: Knowledge, feelings or impressions that a person gains from an event, interaction, original thought or something that stimulates one or more senses. An experience generally has a strong impact on a person and will remain in their memory where they will reflect on it.
S: Psychologically, an experience is a sensory interaction which may be remembered on account of its emotional response. In terms of the scientific process, experience is knowledge resulting from having done something before, which may open up or close down possibilities for future exploration
M: Knowledge gained by creating and understanding of creations, providing vital insights in the process of creation.

Creativity

A: When one can think without restriction to enable the creation of new ideas.
S: To explore and go beyond the confines of normal practise. To experiment in a way that does not have an expected outcome, attempting to see things from a new perspective and being playful with ideas and concepts.
M: The act of making something new or different.

Innovation

A: Problem analyses, often undertaken within the context of the application of new technologies.
S: Application of scientific knowledge to solve challenges in society. More and more, the relentless insistence on innovation potential and impact in fundamental research has made innovation into a perceived barrier to gaining new knowledge.
M: The exploitation of creativity for cultural or social capital

Collaboration

A: Lots of things get called a collaboration. It's better than the hidden labour required to produce the image of a lone genius, but often still a cover for unequal power and unpaid work nonetheless. Collaboration can be empowering, like participatory action and co-design. At its best, collaboration is more than a mere mixture, it is a superposition that co-constitutes the collaborators and the possibilities they produce.
S: A joint activity by several individuals or groups that seek a common goal.
M: Working together by each party bringing different complementary skills to achieve a common goal where the output is greater than could be achieved by any individual working in isolation.

Concept

A: An idea that fuels the need to create. A concept is an idea that has been refined to a point where its edges are defined, allowing connections and contractions to other ideas and concepts to be discussed, explored and tested.
S: Roughly, a part of a natural language which is the general understanding of an idea which is expressed through a collection (commonly an open-ended one) of related terms eg concept of cause subsumes words such as cause, bring about, make, produce etc.
M: A space to keep returning to as a point of inspiration. A process to understand what's behind things through meticulous interrogation to

find the essentials of communicating the truth of an idea.

Curiosity

A: An overwhelming, wild, inexhaustible driving force which needs to be harnessed very carefully.
S: The drive to obtain more information about a specific object or phenomenon.
M: Allowing a series of questions to lead you in new directions, uncovering unexpected outcomes.

Collective

A: 1. Need for a manifesto!?
2. Or many manifestoes!?
3. Or no manifesto; just a shared passion/interest.
S: A group of people engaged in a pattern of inter-related activities which is directed to some common objective through the performance of joint actions
M: Multi-dimensional exploration through shared perspectives, thinking and action.

Community

A: The pool of colleagues you work with or in spite of in your specific area of interest or locality.
S: Collection of people who are unified into an identifiable association by a shared understanding by both awareness of commonality of membership and by possession of sociocultural characteristics that provide marks of membership.
M: A group of people who share skills/tools/resources in order to achieve collective and individual goals.

Impact

A: The effect and affect of an outcome. Used to attempt to quantify success.
S: Collision between two or more objects. Degree in which a product or idea affects or influences others unrelated to its conception.
M: Opening technologies to anyone who is interested in them.

Lab

A: 1. A fashionable word for a shared pop up studio.
2. Scrapheap Challenge but without the cameras, gender bias or Kryten from Red Dwarf.
3. A means of bringing people with diverse skills together for a set period of time to work on ideas and projects; often with a loose association or theme.
S: Short for laboratory. Place specifically designated for and conditioned to perform experiments.
M: Invoking a lab brings both the legitimacy of research, and a sense of the space to explore that come with the craft of prototyping with materials and participants. The MIT Media Lab uses this intersection of science and craft settings well. Perhaps preceded by similar ideas like the Children's Television and Creature Workshops.

Research

A: Research is part of all processes of creativity, some is explicit, like looking for reference images or the right types of glue, and some is more tacit through experiences and connections. There are lots of kinds of research that artists and designers do, and that are done about them. Some of this research is also seen as academic or commercially valuable. Art and design are, in themselves research methods.
S: To obtain more information about a particular subject. Producing a better understanding of a phenomenon or object by meticulous observation, experimentation, simulation and/or mathematical analysis.
M: Investigating materials, processes and techniques so that one can design and make an item or product which is also known as the design process.

Experiment

A: A process which tests the parameters of the creator's curiosity. Experiments are led by improvisation and intuition in terms of decision-making, to explore an idea. To experiment means to begin a conversation about the purpose of our existence.
S: A setting with controlled conditions to allow the testing of a theory or the detection of a rare, sometimes even previously unobserved, event.
M: A process of refinement or material exploration

Practice

A: The action of a practitioner, used to refer to an artist's approach or methods.
S: The process of making a behaviour or action automatic to free mental resources for higher-order executive functions including cognitive flexibility, selective attention, working memory, and inhibition.
M: The process of repeatedly doing something until you are good at it as exemplified by the saying, "practice makes perfect".

Commission

A: 1. A means of supporting artistic creativity.
2. A platform for artists to have work realised and seen by the public.
3. A broken process, more usually ending up as a fabrication brief.
4. An opportunity for an artist to apply their skill/methods in a creative way in order to fulfil a brief whose requirements marry with the clients' needs/ambitions/beliefs.
S: A funded project to produce a piece of work in response to a specific topic or other requirements set out by the commissioner.
M: A formal request to start the art of creation, often funded.

Success

A: 1. Dancing like no-one is watching.
2. One half of the outcome with which to reflect on with equal measure.
3. Impossible to measure but easy to recognize when you achieve it.
S: The discovery of the new, or the unexpected.
M: When a prospective or retrospective desire is achieved through predictable or unpredictable means; usually preceded by moments of frustration and excitement.

Audience

A: Any person or crucial dynamic which denotes groups, often confused with the reason for why people create things.
S: The group of people you aim to communicate your work to.
M: The people who we are making for, the audience are the eventual buyers or users of an object, service or experience.

The Public

A: The people with which I want to share the transcendent, intoxicating experience of existence.
S: Everyone who lives in a society. There are specialist groups of the public which includes "the general public" which is the largest group or

the “interested lay person” which is a small group who have a special and deep interest in a particular topic.
M: A group of people that covers a broad cross-section of society and usually considered non-specialist to what is being presented to them.

Funders

A: Anyone willing to contribute financial backing to a project.
S: Government funded research councils, charities, industry, University Alumni and private sponsors.
M: Any external support that may be available.

Superposition

A: (prefix - The) A loose collective of people in Leeds interested in the joy of discovery.
A: A state where one or more disciplines exist in a collaboration where boundaries are blurred.
A: The place to connect with lively minds.
A: A place to share powerful and contrasting modes of thinking and existing with the world.
A: A place to go and technically engage with how the world works though making and science and then go away to refine concepts to be relevant to more people.
S: “We are the music makers, the dreamer of dreams.”
S: A linear sum of mathematical functions. The physical principle in which two or more superimposed variations in a field or medium will be equivalent to the sum of their amplitudes. In quantum mechanics, a representation of a state as a sum of distinctive vectors in a given orthogonal basis.
S: A group of people who are curious about the world and how they can explore it.
S: Bringing together people with diverse interests and expertise to explore interesting questions and uncover new understanding and enjoyment of the world around us.
S: The homogeneity and additivity of states that is particularly well known for wave mechanics where, for example, constructive and destructive interference of coherent sources lead to diffraction patterns.
S: A great place to be, as in “what a superposition to be in!”
S: Not a place where a scientist becomes less rigorous, but a place where a scientist can be inspired to make a mental leap which can then be backed up in a rigorous manner
M: Multiple states of existence occurring in the same space and time, possibly also multiple views of the same idea or phenomenon.
M: An experiment to see if we can create an arts-cience community in Leeds
M: Where the rigorous engages with the transcendent and the pragmatic
M: A place where a maker can get in touch with conceptual and aesthetic nuances and then go away and build them.
M: A process over time where each discipline can take leaps and engage with aspects which initially feel uncomfortable which then become richer through interaction without fear of collaboration being muddy or unbalanced.

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82 (bottom)	Benedict Philips	2017	Anzir's workbench
83	Benedict Philips	2017	Dr. Samit Chakrabarty giving a talk at ASMbly 2017
86	Dave Lynch	2013	Ghost Sculptures on display at Parkinson Court during Light Night Leeds 2013
87	Dave Lynch	2013	Ghost Sculpture
90	Cat Scott	2017	In Transition
91	Cat Scott	2017	In Transition
94 (top)	Dave Lynch	2013	Dr. Mike Nix and Prof. Ben Whitaker arguing the physics of Unit Cell at ASMbly 2013
94 (bottom)	Dave Lynch	2013	Participants helping at ASMbly 2013
95 (top)	Dave Lynch	2013	Constructing version Unit Cell version 1 at ASMbly 2013
95 (bottom)	Dave Lynch	2013	Unit Cell on display in Parkinson Court during Light Night Leeds 2013
97,98	Lawrence Molloy	2016	Unit Cell version 3 at CFEL, DESY, Hamburg
inner covers	Dave Lynch	2018	Interference M