Our Imperceptible Universe

A experiment in cosmology, art and social science

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Foreword

This exhibition and the publication which accompanies it grow out Dark Matters: An Investigation of Thresholds of (Im)perceptibility across Theoretical Cosmology, Art and Anthropology of Science, a one-year project based at Lancaster University, funded by an AHRC Science in Culture Innovation Award. The project set out to explore the idea of radical imperceptibility. More specifically it was about the provocations and challenges presented to theoretical cosmology, fine art and anthropology of science, by entities, forces and dimensions that currently (or perhaps will always) exceed human and technological modes of sensing and comprehension.

Encounters at the thresholds of human understanding, sensing, knowing, or the possibilities of relationship with the nonhuman - and the vulnerability and exhilaration that these cause - are intrinsic to the project's methodology. On the one hand, claims from cosmology that 95% of the universe is made up of invisible dark matter and dark energy, or that it is possible to mathematically predict the existence of many more dimensions than we are aware of in our known and knowable universe, presents immediate challenges for all three disciplines as they play at the limits of sensibility and relationality with regards to human to nonhuman encounter. How to think and practice with these provocations? On the other hand a different set of challenges are inevitably posed by the complexities and endless possibilities for (mis)understandings by interdisciplinary conversation. As we embarked, in this project, on 3-way conversations, often guided by literature, lectures, observations of disciplinary practices, we found both rich material for discussion and further questioning and in turn used this for each of our own individual research.

For the theoretical cosmologist, when faced with the imperceptible,

Left: Right: *Withdrawn Objects (Nets)* 2015.
Detail.

the imperative is to produce and contest evidence - to ultimately reveal the imperceptible or negotiate the status of the role of speculation. For the artist, the interest lies in interrogating thresholds between the seen and unseen, known, unknown and unknowable, through art practice to enable critical and poetic reflection. For the anthropologist, the category of the imperceptible provokes a questioning and further pushing of the limits of human subjectivity, experience and sensibility in relation to the inhumanly (un)manifest.

The project develops a broader realization that research into what lies presently (and perhaps always) beyond human and technological modes of sensing has serious implications for a wider spectrum of disciplines involved in understanding earthly and non-earthly processes (e.g. atmospheric and biodiversity science). We have come to ask 'What do touch, intimacy and relationship – which imply 'making a difference' in material and emotional terms– come to mean when encounters are radically non-immediate and yet insensibly ubiquitous? In other words, how might we learn to be affected when an exchange of properties is utterly unknowable?

With this in mind, Casey's drawings emerging from the project do not seek to illustrate the intriguing and complex phenomena of cosmology, rather they reflect on the conditions of their unknowability. We can only see as far as the light allows and looking out into space is looking back in time. Light which started its journey beyond 13.8 billion light-years ago has yet to reach us because the Universe is 13.8 billion years old …. and as the universe is currently expanding in an accelerated rate it will never reach us. Moreover, there is matter, dark matter, everywhere, beyond the solar system and in this room, which cannot be revealed by light. The new drawings presented in the exhibition reflect upon what it feels like to encounter the radically remote, that which is on the edge of our grasp or just out of reach.

Rebecca Ellis
Kostas Dimopoulos
Sarah Casey

November 2015

Postcards from the Edge of the Universe

Kostas Dimopoulos

Above: Studio test for *Light Fossil*

Dark Matter

Non-luminous but transparent non-relativistic matter, which is more than five times the baryonic matter (that makes planets, stars and us) in the Universe at present. The existence and abundance of dark matter is indicated by a number of independent astrophysical and cosmological observations. Among other things, dark matter holds the galaxies together (otherwise they would fall apart because they are spinning too fast) and is essential in the structure formation process (the gravitational collapse of galaxies and their clusters), where the distribution of luminous matter traces the gravitational potential wells of dark matter. Non-luminous matter has experimentally been discovered (neutrinos) but it is relativistic, while non-relativistic matter (our atoms) is luminous (can be seen/ detected). The dark matter particle is still elusive (prominent hypothetical candidates are neutralinos, gravitinos and axions).

Dark Energy

The majority of the Universe content at present is attributed to a substance, which has profound implications for the Universe dynamics and is not the usual relativistic (radiation) or non-relativistic (dark and baryonic) matter. The existence of such so-called dark energy, forces the Universe expansion to speed up (accelerate). The most promising candidate for dark energy is vacuum density, due to quantum fluctuations. Even though the existence of quantum fluctuations has been experimentally confirmed, it is a mystery why the vacuum density they give rise to is so small. A closely related alternative possibility is a non-zero cosmological constant (no substance). The required magnitude of this constant is also a mystery but it can be understood in an anthropic way under the multiverse hypothesis. This possibility needs to set the vacuum density to zero, by a yet unknown mechanism.

Cosmic Inflation

A period of superluminal accelerated expansion in the Early Universe, caused by domination of the Universe content by a dark energy substance. It solves in a single stroke the horizon and flatness problems of the Hot Big Bang cosmology, while also accounting for the origin of cosmic structure (i.e. the distribution of galaxies) by amplifying quantum fluctuations of suitable fields, giving rise to the observed primordial density (or curvature) perturbations. As such it imposes the Cosmological Principle (the Universe is homogeneous and isotropic) and the necessary deviations from it as an initial condition for the Hot Big Bang. In a sense, it may also be responsible for the Universe expansion itself.

Spacetime Foam

When the energy density in the Universe is extremely high (for example near the central singularity of black holes or near the Big Bang singularity) the quantum effects of gravity become important, so spacetime is no more a smooth background but it is filled with wiggles, hooks and loops. This foamy structure of spacetime gives rise to black hole (or wormhole) quantum nucleation, the formation of baby universes (which detach from the parent universe capturing information away) and closed timelike curves (which are loops in time that violate causality as an event can cause itself). Spacetime foam is thought to be realised before (or beyond) cosmic inflation at the onset (or edge) of the Universe existence. Because causality and linear time are invalid within spacetime foam, this refutes the argument of `prima causa' of Thomas Aquinas.

Extra Dimensions

In an effort to unify the known fundamental forces in nature (gravity, electromagnetism, weak and strong nuclear interactions) in the context of a yet unknown Theory of Everything, potential candidate theories (such as string theory or supergravity) have postulated the existence of six (or sometimes seven) extra dimensions to the four (three of space and one of time) that we experience. In contrast to the four open dimensions of conventional spacetime, the extra dimensions are thought to be closed and compactified to a very small size (hence undetected so far). The shape and size of the compactified space determines the form of physics in our world. Thus, the strength and character of our "fundamental" interactions reflects the geometrical characteristics of these extra dimensions.

Large Extra Dimensions

In a variant of the extra dimensions postulate, the particles and fields that make the content of our world may be confined to a 4-dimensional (mem)brane floating in 10(or 11)-dimensional bulk space. Only gravity can freely move to and from our brane, even though a warp factor in the spacetime metric makes sure that gravity is felt only weakly in our world. The existence of large extra dimensions makes it possible to generate tiny black holes inside accelerators (such as LHC in CERN), but these are not a danger because the theory dictates that they immediately evaporate through emission of Hawking radiation.

$$\Lambda^{9}_{\mu}+i\Lambda^{10}_{\mu}, \quad G^{1}_{\mu}=\Lambda^{1}_{\mu}+i\Lambda^{2}_{\mu}$$

$$\Lambda^{11}_{\mu}+i\Lambda^{12}_{\mu}, \quad G^{2}_{\mu}=\Lambda^{3}_{\mu}$$

$$=\Lambda^{13}_{\mu}+i\Lambda^{14}_{\mu}, \quad G^{3}_{\mu}=\Lambda^{4}_{\mu}+i\Lambda^{5}_{\mu}$$

$$=\Lambda^{16}_{\mu}+i\Lambda^{17}_{\mu}, \quad G^{4}_{\mu}=\Lambda^{6}_{\mu}+i\Lambda^{7}_{\mu}$$

$$=\Lambda^{18}_{\mu}+i\Lambda^{19}_{\mu}, \quad G^{5}_{\mu}=\Lambda^{8}_{\mu}$$

$$=\Lambda^{20}_{\mu}+i\Lambda^{21}_{\mu}, \quad W^{+}_{\mu}=\overline{W^{-}}_{\mu}$$

$$=\Lambda^{22}_{\mu}+i\Lambda^{23}_{\mu}, \quad W^{3}_{\mu}=\Lambda$$

String Landscape and The Multiverse

The size and shape of the postulated compactified extra dimensions in string theories is stabilised by the existence of suitable fluxes of fields that live in the compactified space. This means that only specific geometries (Calabi-Yau manifolds) are assumed by the compactified space. However, the number of the possible Calabi-Yau's is huge (but not infinite), which allows a vast multiple of realisations, each with its own structure of physical laws and its own strength of interactions. Our Universe is only one such possibility. Now, there is a physical mechanism to populate these possibilities and give rise to an ensemble of different, so-called pocket universes. This ensemble is called the Multiverse. Pocket universes are separated by regions where space is undergoing eternal inflation (never-ending superluminal expansion) but they may be connected through wormholes (spacetime "bridges"). Even though an untestable hypothesis, the existence of the Multiverse can explain away (by anthropic reasoning) certain fine-tunings by rendering fundamental constants, into environmental quantities, which assume different values (strengths) in different pocket universes.

Left: Extract from one of Dimopoulos' papers

"In an important sense, touch is the primary concern of physics. Its entire history can be understood as a struggle to articulate what touch entails. How do particles sense one another? Through direct contact, an ether, action-at-a distance, forces, fields, the exchange of virtual particles?.....

Once you start looking at it this way, you get a dizzying feeling as things shift. This particular take on physics, and its history, may entail a torquing, a perturbation from the usual storylines, but it is far from a gross distortion. I offer this twist on the usual framing as a provocation for opening up new ways of thinking about both physics and touch."

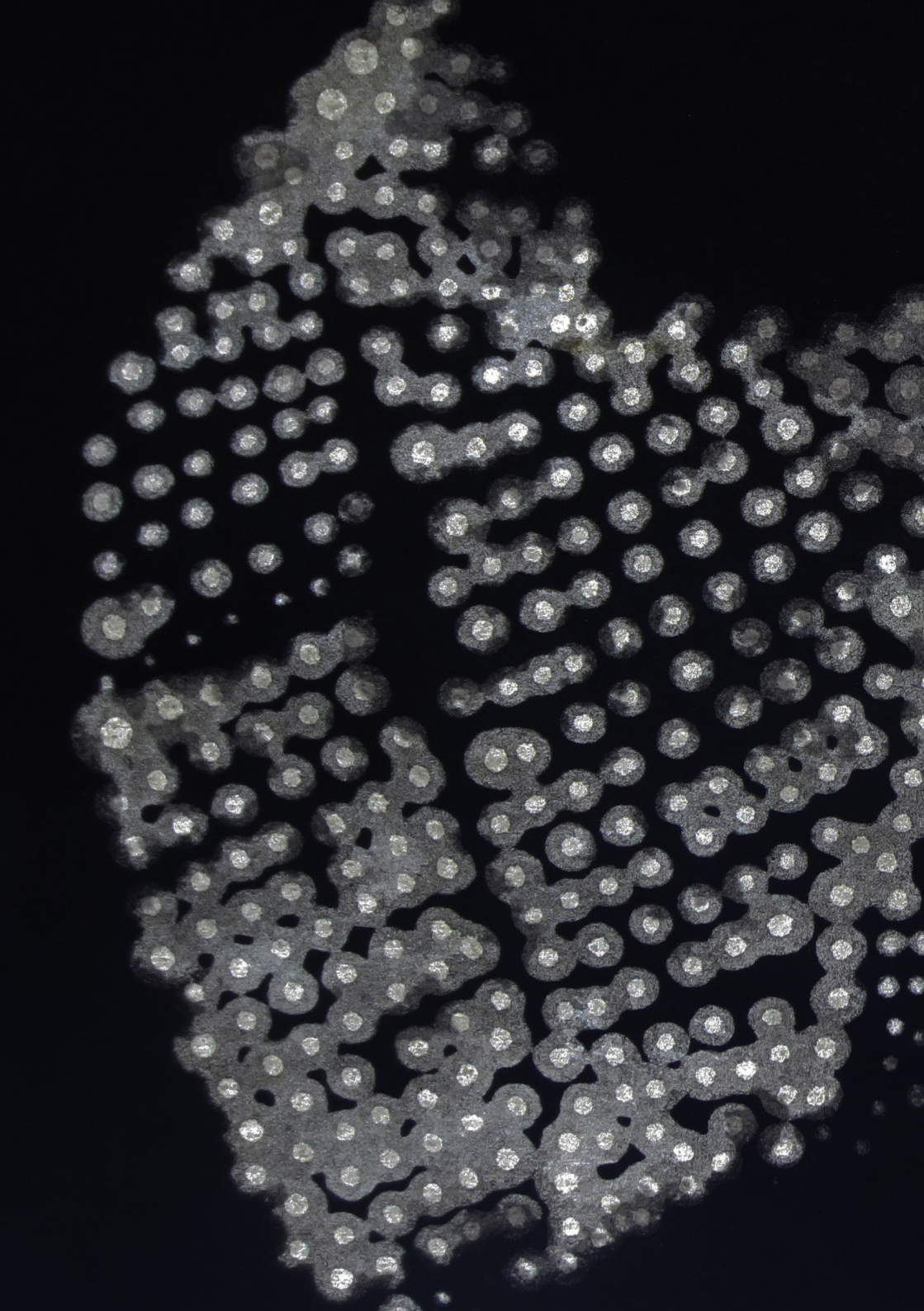
Karen Barad

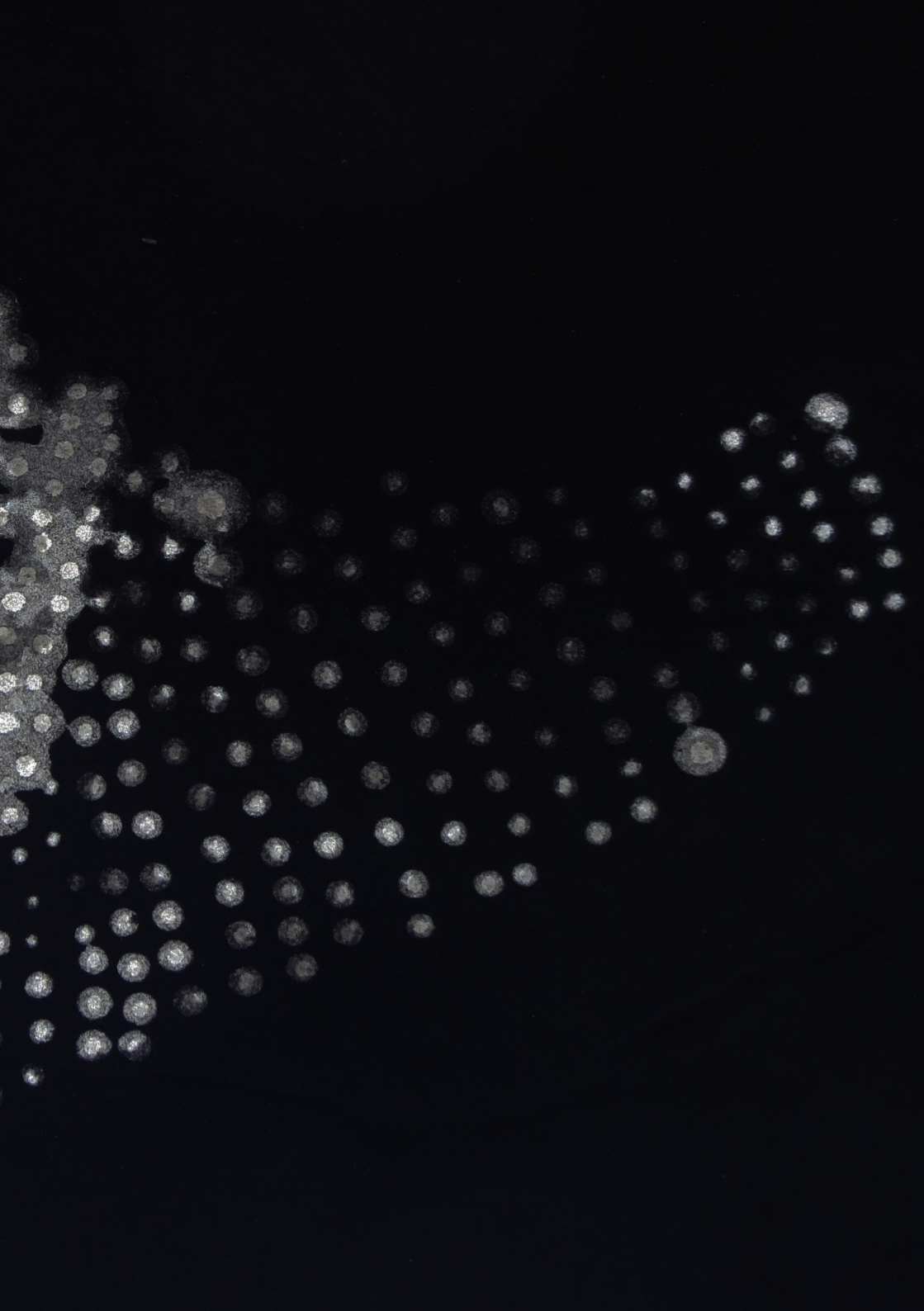
Barad, K, 2012 Differences p.208

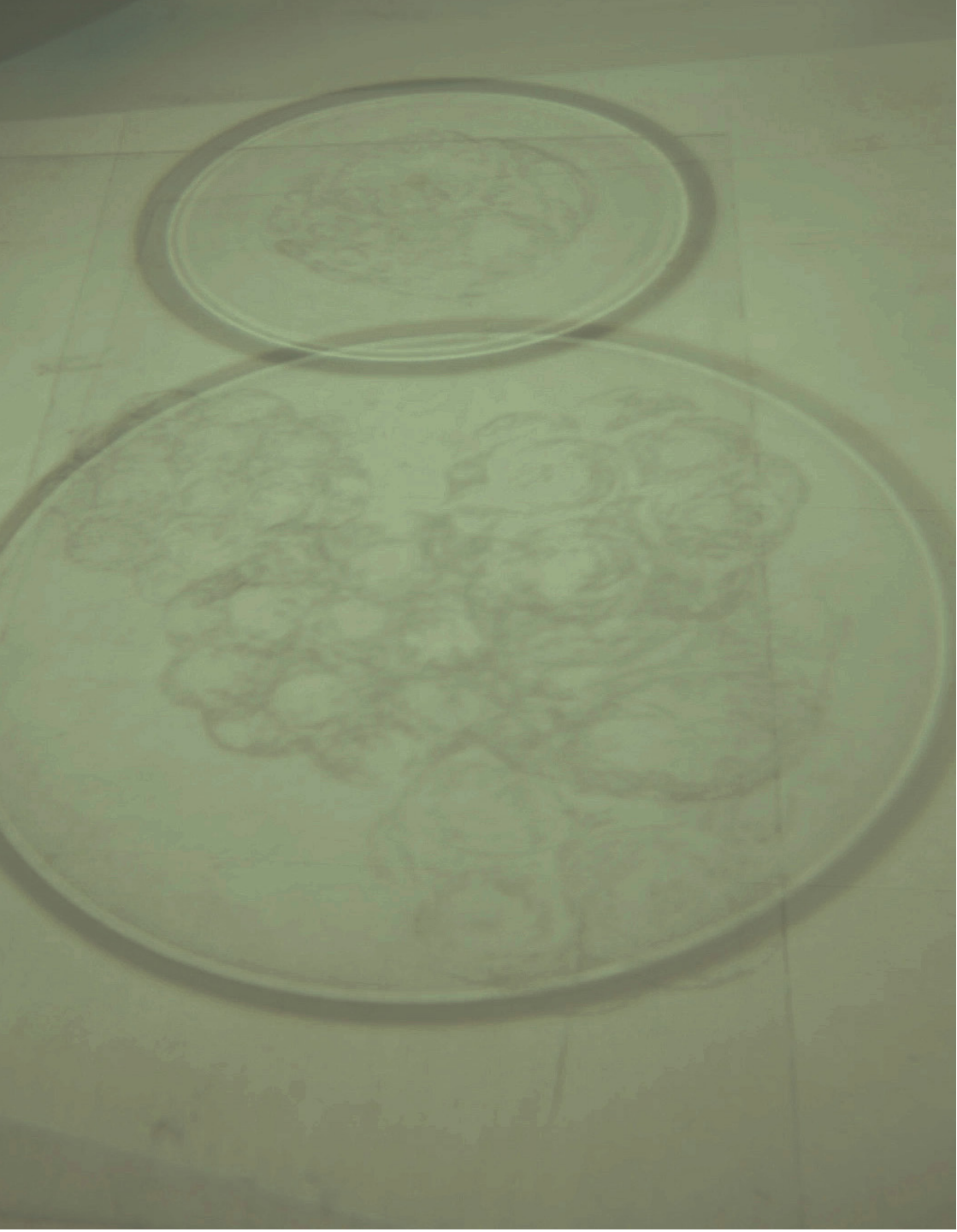
"Because I hold things cannot be defined by how they affect other things, it follows that it's possible that there are things that affect no other things at all. I say it's possible, not that they do exist. How would I know? In order for me to know that they exist they would have to produce some sort of difference with respect to me or the social and natural world with which I dwell."

Levi Bryant

Levi Bryant, https://larvalsubjects.wordpress.com/2011/05/25/dark-objects/







Above: *Messengers.* Detail.
2015
Shadow

Luminous matter traces the form of the dark matter...

Drawings by Sarah Casey

Above: *Withdrawn Objects (Nets) 1* Detail.
2015
Blue ink and burn on paper

Dark Objects
Drawing the (Im)perceptible

Drawings in their creation, ultimately address states of being and not being. In drawing, the drawer is bringing something into being, giving presence to an idea, making visible the invisible, the thought, the idea, and inscribing it into the world. The drawing both has a presence of its own, and invokes the presence of an absent other: it is both, paradoxically, present and absent. These ideas inform the drawings here which are stimulated by ideas of parallel worlds, perhaps pressed close up to our world but ultimately inaccessible.

Working on the project it struck me that cosmology is able to deal with subjects at a distance, without visual or sensory confirmation of their existence. Cosmology might be likened to forensics – an activity of piecing together information, using experience and theory to make the most probable story. A radical archaeology; we are after all talking about remoteness in time as much as remoteness in space. Tony Godfrey has described drawing as a form of archaeology, 'an archaeology of act of touching' [1]. Drawing is an activity of marking, of leaving a trace and inscription that carries within it the time of its making and the touch of the maker. The group of works *Messengers* came from this idea of drawing as a type of go-between activity, and thinking about the 13.8 billion year journey that light takes to reach us from the first seconds of our universe. Light is our messenger from the early universe. Cosmologists speak of 'light fossils', traces of old light etched into the fabric of our cosmos which act as clues to the physical processes that shaped the universe we know today. The *Messengers* drawings are scored into glass, making the drawing itself virtually impossible to detect, we only see its shadow projected on the wall.

Many of the works rely on indirect viewing or have arrived out of counter intuitive process. *Light Fossil* is similarly made by shadow and the lines in *Withdrawn Objects*, made with navy blue ink on

indigo paper, only appear after the ink has dried with a coppery sheen on its surface. These works I've been making try to articulate a sense of relationship- or knowing- that comes in and out of orbit. The idea of a 'dark object', as described by the speculative realist, Levi Bryant has particular appeal. No matter how closely we study an object, it contains within it that which is forever other to us and therefore unknown. It is in this unknowing that wonder resides.

Thinking about the edge of the universe, if there is such a time or place- distant in space but also time- led to thinking about historical objects, materially present but oblique and inaccessible in their meanings, for instance Scottish carved stone balls or the spells in the Pitt Rivers Museum, Oxford. In being 'withdrawn' in the sense that they keep their past to themselves, these museum artefacts offered poetic parallels with the cosmologically imperceptible. For instance, the parallel universes that we can never know and other phenomena beyond the reach of light. It is no accident that these drawings are elusive. Rather than reveal the image of a subject, they are enigmatic, offering only fragments and glimpses, which seem to thwart viewing. They seek not to depict the look of these dark objects, but the sense of uncertainty and mystery we sense on encountering them.

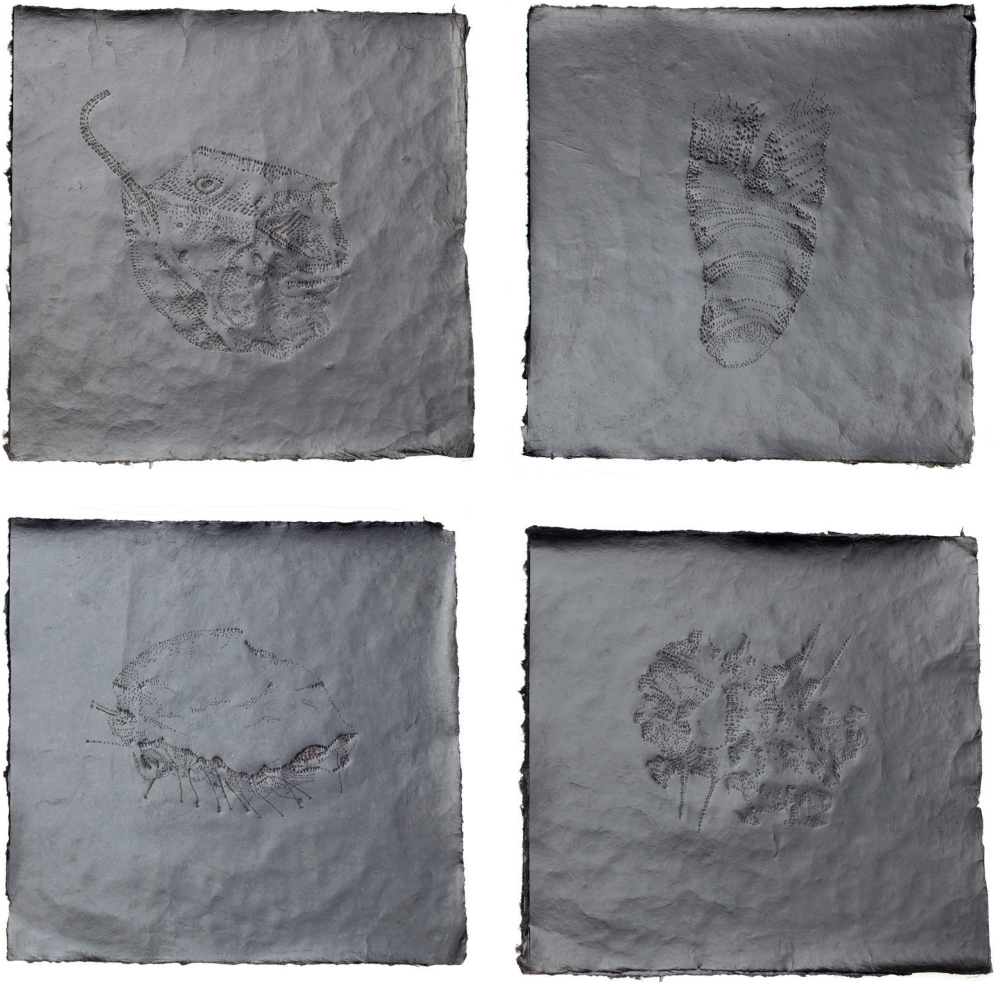
Sarah Casey

November 2015

NOTES

1.Godfrey, Tony, *Drawing Today Draughtsmen in the Eighties* (Oxford: Phaidon, 1990) p.9.

Right: *Withdrawn Objects (Nets) 2*
2015
Blue ink and burn on paper

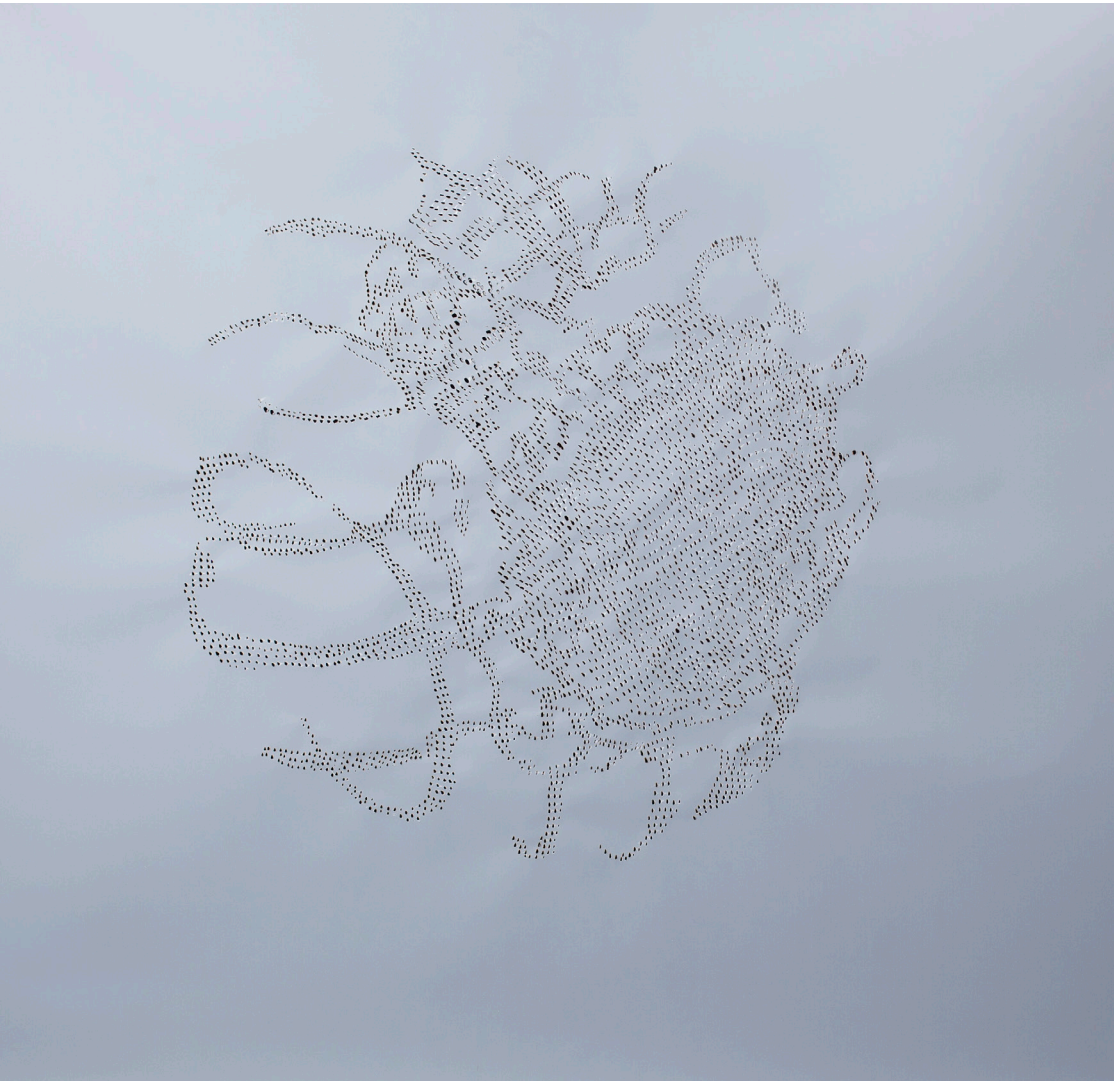


Above: *Dark Objects (Spells)*
2015
Graphite & Burn on paper

Above: *Dark Objects (Spells) 3*
2015
Graphite & Burn on paper

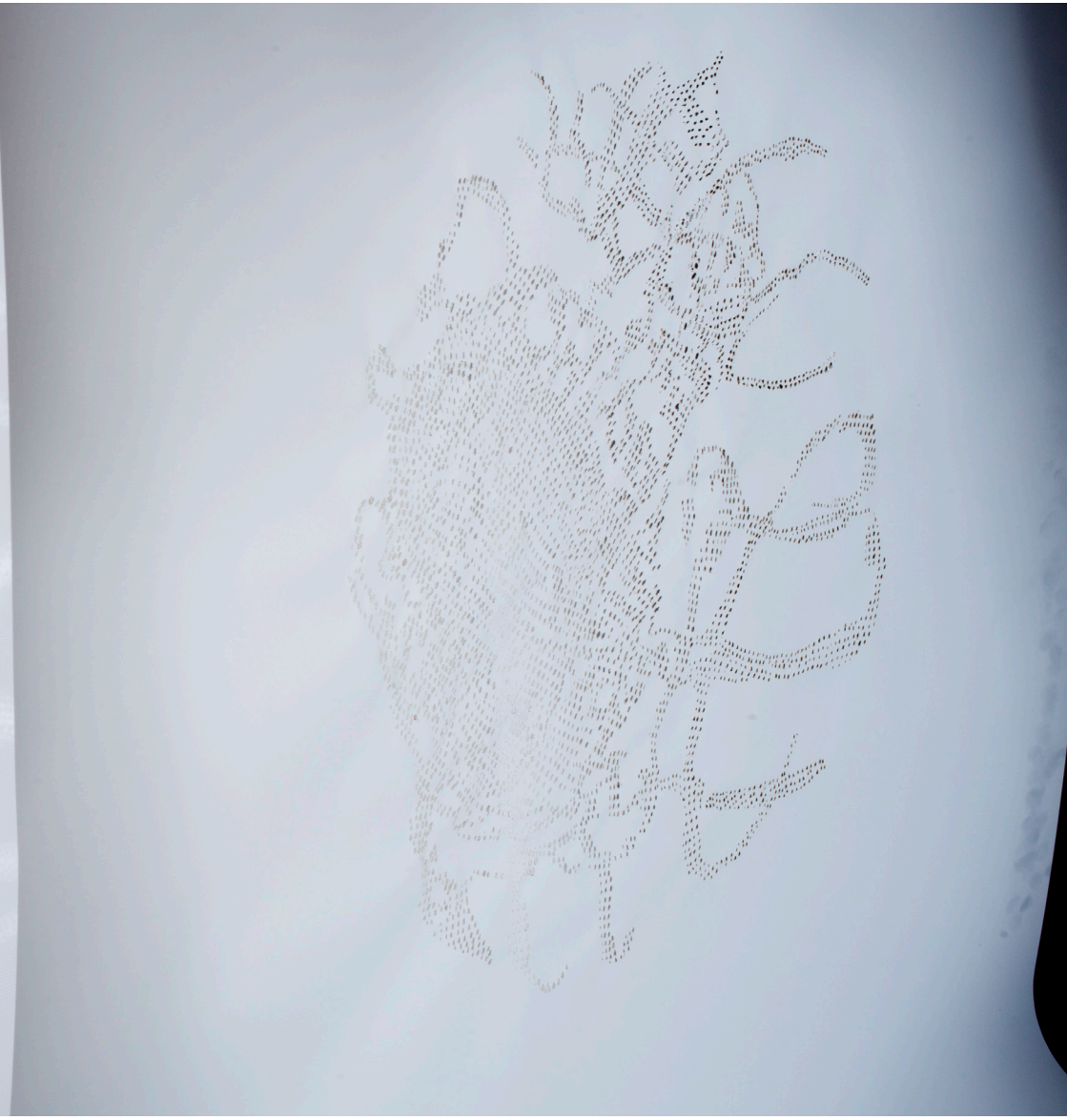
Above: *Dark Objects (Spells) 2*
2015
Graphite & Burn on paper

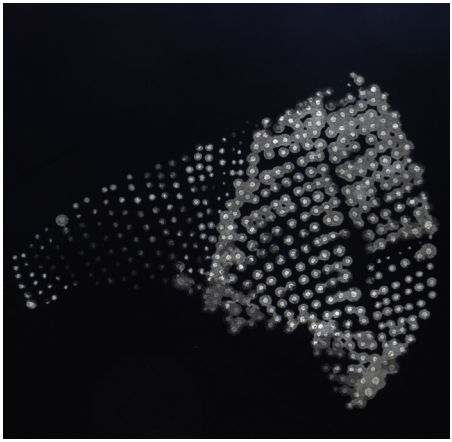
Above: *Dark Objects (Spells) 4*
2015
Graphite & Burn on paper

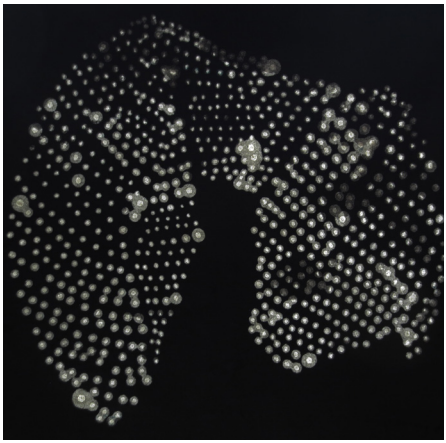


Above and left: *Light Fossil 1* (Detail)
2015
Burn on Mylar

Above: *Light Fossil 1*
2015
Burn on Mylar







Above: *Dark Objects (Fragments)*
2015
Oil and ink on paper

Contributors

Kostas Dimopoulos

Kostas Dimopoulos is reader in Theoretical Cosmology at Lancaster Univeristy. His core research area is Particle Cosmology with a focus on Cosmic Inflation. This can be defined as a period of accelerated expansion of space in the Early Universe. His research regarding Inflation aims to construct and study the dynamics of realistic inflationary models based on Particle Theory. Another area of research is the possible generation of large-scale Primordial Magnetic Fields in the Early Universe. Such fields can be responsible for the observed intergalactic magnetic fields as well as the magnetic fields of the galaxies themselves. More recently Dimopoulos has pioneered the study of the effects of vector boson fields and shown that, under certain circumstances, vector boson fields can contribute significantly or even be solely responsible for the generation of the Primordial Density Perturbation (PDP). The PDP is generated by inflation and is responsible for the formation of galaxies and galactic clusters.

Rebecca Ellis

Rebecca Ellis is an Anthropologist and Senior Lecturer in Human Geography, Lancaster University. Her research draws upon the disciplines of Social Anthropology, Science and Technology Studies and Cultural Geography to probe various interstitial spaces between knowing and not knowing, between manifest and unmanifest presence introduced by (in)organic entities, forces and dimensions, as resources for theorising the experience and politics of human-nonhuman (non)relationality. She is the principal investigator on the Dark Matters project.

Sarah Casey

Sarah Casey is an artist and researcher in Fine Art at Lancaster University. She makes drawings which test the limits of visibility and material existence. This practice reflects a fascination with the unseen, untouchable and unspoken. Drawing is a means of exploring what it means to see, touch and feel experiences on the edge of our grasp.

Over the past decade she has taken drawing to a range of challenging environments, working alonside researchers in a range of fields to see what the activity of drawing may share with other practices that must negotiate the delicate to reveal the unseen. Cosmology presents a radical example of grappling with subjects at the absolute limits of human 'touch'. She has a PhD in Drawing and exhibits nationally and internationally. Her work was shortlisted for the Jerwood Drawing Prize 2014.

Solo Exhibtions

2015 Common Grounds, The Bowes Museum, County Durham
2013 Hidden Drawers, Kensington Palace, London
2012 Drawing the Delicate, Peter Scott Gallery, Lancaster

Selected Recent Group Exhibitions

2015 Paper, table, wall and after, Taipei, Taiwan
2015 Drawn Conversations, Coventry University, UK
2015 Beyond Perception, University of Aberdeen, UK
2014 Jerwood Drawing Prize, Jerwood Space, London & tour
2013 Darkness at the Edge, Propeller Visual Arts Center, Tornoto, Canada
2013 Sketch Drawing Prize, Rabley Drawing Centre, Marlbough
2013 Drawing Open, Salisbury Arts Centre, Salisbury
2011 Sketch Drawing Prize, Rabley Drawing Centre, Marlbough
2010 Paper Works 3: British Artsists working with Paper, Bury Art Gallery & Museum, Bury
2009 5th Interational Drawing Biennale, Melbourne, Australia
2009 The Art of Research, TAIK, Helsinki, Finland

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