

The Hands-On Universe: Making Sense of the Universe with All Your Senses

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For the past four years, the Hands-On Universe public engagement programme has explored unconventional, interactive and multi-sensorial ways of communicating complex ideas in cosmology and astrophysics to a wide variety of audiences. The programme lead, Roberto Trotta, has reached thousands of people through food-based workshops, art and science collaborations and a book written using only the 1000 most common words in the English language. In this article, Roberto reflects in first person on what has worked well in the programme, and what has not.

Introduction

On a balmy evening in June 2015, I took my seat as a member of the general public at Cheltenham Science Festival, UK. It was a sold out event in the festival's programme, and Professor Charles Spence, of Oxford University's CrossModal Research Laboratory, and experimental chef Jozef Youssef of Kitchen Theory¹, charmed the audience with a talk about their ongoing collaboration. The chef and the scientist (as they like to present themselves) described their exploration of how multi-modal sensorial experiences influence the way we perceive (and enjoy) food. The scientist sought novel insights on how the brain operates: did stroking a velvet surface as opposed to a rough one increase the sense of sweetness in food? Answer: yes, as was exemplified in a classic experiment going back to Italian futurist Filippo Marinetti, who presented it in a futurist cookbook in 1932 (Marinetti, 1932, 2014). On the other hand, the chef wanted to use the latest insights

of experimental psychology to create surprising, multi-sensorial dining experiences for his guests [Bosker, 2015].

At the end of the talk, after everybody else had left, I approached Jozef: 'Have you ever thought about what dark matter might taste like?', I asked him. 'I haven't, but we can!' was his reply. This was the start of a journey together that would lead to the g-ASTRONOMY project, part of a series of public engagement activities I created and presented in the UK and abroad, and to some of the most memorable and moving moments in my public engagement work to date.

The series of activities — called the Hands-On Universe Project² — aimed at lowering access barriers for the public to topics in astronomy, cosmology and astrophysics. The common thread of the various activities was to generate curiosity and engagement by moving away from purely intellectual explanations, in favour of more interactive, multi-sensorial and dialogic means of engagement. Funded by the Science and Technology Facilities Council (STFC) (one of the seven research councils in the UK), the project ran for four years until September 2017, during which time I had the privilege of being an STFC Public Engagement Fellow. Being a fellow meant that part of my salary was covered by an STFC grant, which freed up some of my time as an academic member of staff at Imperial College London to work on the Hands-On Universe project. After more than a decade of doing science communication in my 'free' (and often, family) time, the grant gave me the opportunity to pursue it as an official part of my job. This made a huge difference: I now had

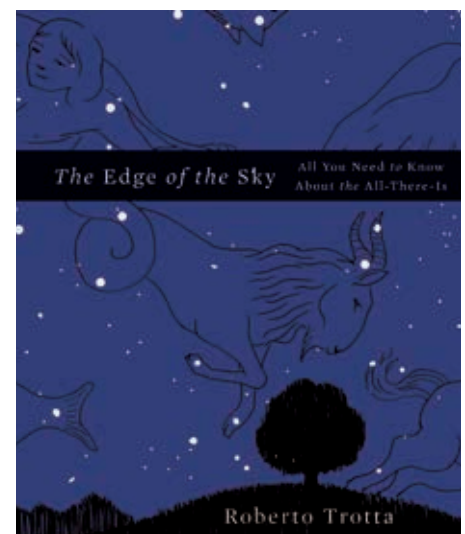


Figure 2. The cover of Roberto's book, 'The Edge of the Sky', written using only the 1000 most common words in the English language. Credit: Antoine Déprez

the time to design and implement a coherent engagement plan and the resources to run it.

My research as an astrophysicist at Imperial College London, UK, deals with some complex and faraway concepts such as dark matter, dark energy and the Big Bang. But as a science communicator and educator, I had been asking myself for years how we can make some of the most difficult concepts in modern physics fun, engaging and accessible to all. The Hands-On Universe project grew out of my quest for novel ways of engaging the public with my subject, often perceived (for right or for wrong) as inaccessible. After giving hundreds of public talks and lectures over the years, I had grown a little disillusioned with traditional public engagement for-



Figure 1. The Hands-On Universe project logo. Credit: Hands-On Universe



Figure 3. Roberto presenting the Great Cosmic Cookery Show at Imperial Festival 2014. Credit: Imperial College London

mats. I was particularly wary of the top-down model of engagement generated by the lecture format — the scientist speaking, the public taking it all in, and perhaps asking questions at the end. I felt it would be much more enriching for both parties if a format were used that enabled a more dialogic encounter between the scientist and the public.

This was the starting point for the project, which had three main, intertwined strands. The first aimed at using multi-sensorial experiences based on food to create original and engaging metaphors for concepts in astrophysics ('g-ASTRONOMY'). The second strand was to foster art and science collaborations to widen participation to sectors of society not traditionally interested in astronomy. And the third strand used my book, *The Edge of the Sky: All you need to know about the All-There-Is* (which talks about modern cosmology using only the 1000 most common words in the English language [Trotta, 2014]) as a way of reaching both very young children and adults interested in creative writing.

g-ASTRONOMY: Beyond Visual Representation of Astronomy

The g-ASTRONOMY strand of the Hands-On Universe programme set out to test the idea of using food as an engaging yet scientifically accurate metaphor for astrophysical phenomena. After all, food

concerns us all, and we all have a relationship with it.

I have been working with food in my engagement work for some time. I have used focaccia bread to explain the expansion of the Universe, worked with school children to build a to-scale Solar System



Figure 4. An edible Solar System developed with experimental chefs using a technique called 'spherification' to produce the planets, presented at an event at the London Science Museum in December 2015. The asteroid belt is made of chocolate crumble, and other minor bodies (including comets) are made of edible silver flakes. Credit: Imperial College London



Figure 5. Children exploring the makeup of the moon with muffins at a Hands-On Universe workshop for families. Credit: Roberto Trotta

from fruits and vegetables (with peppercorns for the asteroid belt!), and developed a travelling cookery show based on early Universe cosmology. In fact, when I first met Jozef Youssef at the Cheltenham Science Festival, I was there to present 'The Great Cosmic Cookery Show', an event for families which aimed to use cookery as a fun and interactive way to talk about space. Children and their parents thus explored black holes with 'Spacetime

Tortillas', built a replica Solar System with fruits and vegetables on skewers, baked 'Moonberry Muffins' to explore gravity and the formation of moon craters, and created a 'Nuclear Sunrise' cocktail representing the chemical makeup of the Sun. The whole thing was messy, memorable and surprisingly scientifically accurate.

The ongoing collaboration with Jozef Youssef and his development chefs, took

my own early experiments using food for science engagement to a new level of sophistication. Youssef and his team of trailblazing chefs devoted to multi-sensorial dining experiences, have brought the expertise of professionals to bear onto the question of how to communicate cosmology and astrophysics with food. g-ASTRONOMY aims to break the assumption that astronomy and astrophysics can only be understood in terms of visual representation. Instead, we wish to create simple, elegant (and edible) metaphors for some of the Universe's most complex ideas, so as to enable people to engage with some of the most important theories in astrophysics in a new, accessible and delicious way.

Our collaboration produced an edible orrery of the Solar System, with visitors of London's Science Museum invited to create their own edible planets with a technique called 'spherification' — producing liquid spheres encapsulated in a thin membrane that burst in your mouth in an explosion of taste.

For the Cheltenham Science Festival 2016⁵, we created a cocktail named 13.796, after the age of the Universe in billions of years, which was inspired by the cosmic timeline from the Big Bang to the present day. Served in a martini glass, which signifies the expansion of the Universe, time in the cocktail flows from the bottom up. The cocktail is composed of three layers of decreasing density that do not mix with



Figure 6. Chocolate pralines designed to express various corners of the multiverse in a multi-sensorial fashion. The weight, texture and filling metaphorically match the properties of the pocket universes they represent. Credit: Stefano de Constanzo



Figure 7. A delicate parmesan tuile is used to grasp the properties of Einstein's space-time and the existence of dark matter in the Universe. Credit: Stefano de Constanzo

each other. Each layer relates to a cosmic epoch: the early Universe plasma at the bottom (mango smoked with wooden chips from whisky barrels), the dark ages when the Universe became transparent (jellified coconut Malibu) and the formation of the first galaxies (coconut water with a suspension of vanilla pods). A scientifically accurate, utterly delicious and slightly inebriating representation!

Other outputs created as part of the project included a parmesan tuille which encapsulated the distribution of galaxies in the sky and Einstein's notion of a malleable space-time continuum — a tool used to explore the meaning of 'cold' vs. 'hot' dark matter.

We also presented the speculative notion of a Multiverse with different pocket universes, each with its own laws of physics and different constants of nature, using three chocolate pralines. Their contents, texture, and density were carefully chosen to embody an empty universe, an over-dense universe, and our own, finely balanced Universe, with its 25% dark matter (chocolate crumble), 70% dark energy (coffee-milk chocolate ganache) and 5% all-important normal matter (passion fruit gelatine).

Building on the learning from the project so far, we have now embarked on an even more challenging project: in collaboration

with the Royal National Institute of Blind People, we designed an event exclusively for people with sight loss, which we ran for the first time in London, UK, in March 2017⁴.

The workshop has been specially designed to provide an immersive and interactive experience without the need for visual cues. Visitors are able to simultaneously feel and taste the evolution of our Universe from the Big Bang to the formation of galaxies and experience the multiverse theory through how different universes might taste, rather than how they look. The cocktail was also modified to use in the workshop. It was broken down into three different sections, with the first one served in specially designed 3D-printed cup holders that reproduce in a tactile form the 'bumps' in energy found in the baby Universe. These energy bumps are based on data from the cosmic relic radiation collected by the microwave satellite Planck. The 3D printed cup-holders have been created by Imperial College London's Advanced Hackspace, and build on previous work by Dr David Clements, also at Imperial.

The feedback from participants with visual impairment has been very humbling and encouraging: *'I have never experienced anything like it before'; 'I cannot stop thinking about it!'; 'Life changing'*. The g-ASTRONOMY project is about using all of our senses to better communicate complex

ideas in astronomy and astrophysics, and it has been a privilege to work with people with sight loss to better understand how to take the concept forward. The insights and feedback of this group will shape the next phase of g-ASTRONOMY: moving away from edible tableaux of astronomical ideas and exploring deeper analogies in terms of the physics at work both in the Universe and in the kitchen.

Art and Science Collaborations

With the Hands-On Universe programme, I explored the arts as another route to reach a different kind of public than people already interested in astronomy. I have long been interested in art and science collaborations as a way of exploring a genuinely new territory between the two. Sometimes, such collaborations end up providing a mere 'artist's impression' of a scientific concept, which is often unsatisfying for public engagement purposes. At the opposite end, they might provide not much more than a veneer of scientific respectability on a pre-existing artistic concept. In order to be truly cross-disciplinary, an art and science collaboration has to leave the safety of both the artist's and the scientist's territory; become unmoored and explore an approach that is genuinely in-between.



Figure 8. 3D printed cup holder showing in a tactile fashion the distribution of temperature in the very early Universe, as measured by the Planck satellite. The size of the holder matches the size of the visible Universe at 10^{-34} seconds after the Big Bang. The smoked mango drink is a representation of the primordial plasma that filled the Universe at that time. Credit: Tom Walker

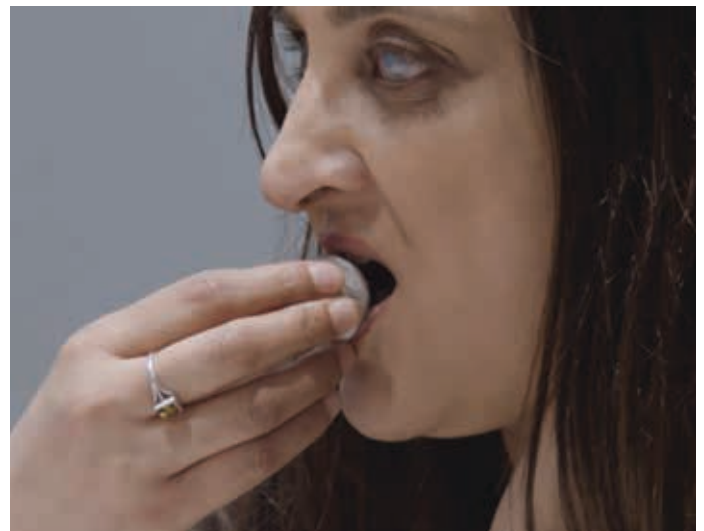


Figure 9. One of the participants at the g-ASTRONOMY event for visually impaired people enjoys a taste of the Multiverse. Credit: Tom Walker

The very real danger in creating a project outside of either discipline is that the outcome may not be satisfactory from either point of view. This risk, however, is usually worth taking and when the chemistry is just right both the artist and scientist can come away feeling that together they have achieved something that neither of them could have done alone. A collaboration that left this positive impression on me was with the artists Ole Hagen and David Cheeseman. Ole, David and myself had been discussing ideas at the boundaries of our respective work for several years — in 2013, one of our proposals even made it into the 100 best proposals for the UK art competition Artangel. Out of these long-standing discussions and exchange of ideas grew the show 'All There Was', presented at the Institute for Contemporary Art Studio in London as part of a year-long series of 50 shows in 50 weeks [Ustek, 2018]. The title of the exhibition came from the three most frequently used words in my book, 'The Edge of the Sky'.

The opening night of the show saw a performance piece, in the form of a conversation ('Does Darkness Matter?') between Ole and myself, revolving around our respective approaches to knowledge in the Universe. As the dialogue moved on, we sketched our ideas on opposite ends of a specially designed concertina-shaped blackboard, which upon unfolding revealed the unsuspected meeting of the two perspectives in the middle. The show consisted of seven sculptural pieces created by Hagen and

Cheeseman as a reflection on the 'Big Seven' features of today's post-Newtonian Universe which were identified by our conversations: dark matter, dark energy, inflation, the Higgs particle, exoplanets, black holes and supersymmetry.

What we were interested in exploring with the show were the boundaries between science and visual art, including concept, hypothesis, meaning, representation and communication. It was very stimulating for me to snap out of the usual scientific perspective of the concepts we had identified. Together, we looked at these ideas from the point of view of Cheeseman's interest in illusion, in the haptic and experiential encounters with objects and in experiments using mirrors and magnets. Hagen's multidisciplinary approach brought to our relationship an investigation of theatricality, myth-making and cosmology. Ultimately, our efforts converged in a show that was trying to depict and grasp the invisible, both in art and astrophysics.

Lessons Learnt

Inevitably, looking back at the Hands-on Universe project now that it is over, there are a few aspects of it that I would do differently. It is important to step away from the culture of positive reporting and talk about the shadows, as well as the highlights, as this allows us to reflect critically and to improve in the future.

Perhaps my biggest regret is that I have allowed myself to be overly driven by my enthusiasm for the project. This meant that it was difficult for me to ever say no to the enticing requests I received. As a result, I ended up giving talks and leading workshops aimed at audiences that perhaps did not really need to be stimulated, as they were already very much on board with the broad aims of my work. In other words, I wish I had dedicated a larger fraction of my time and efforts to the more difficult-to-reach audiences, rather than giving in to hugely satisfying (but arguably less important) opportunities to talk to science-minded and science-savvy audiences.

Another aspect I now realise I did not pay sufficient attention to is evaluation. While evaluation often has a reputation for being a boring and bureaucratic way of measuring things that are difficult to quantify (audience engagement, change of perspectives, lasting value), I wish now that I had made a more consistent and sustained effort. It would be useful to have more precise statistics on the public I reached — gender, background, education level, age, etc. — to enable me to better answer the fundamental question at the heart of most science communication: 'Did it make a difference?'. Ultimately, this is a very difficult concept to measure accurately (or at all), but it constitutes perhaps the central question of any public engagement work.

After four intense and fun-filled years designing and delivering the 'Hands-On Universe', I will now concentrate my efforts on further developing the g-ASTRONOMY programme. While my work with Kitchen Theory is only in its infancy, I sense a great potential for this collaboration. Everybody I spoke to about it has been supportive, perhaps stimulated by the surprise factor and the many possibilities that this concept opens up for reaching new audiences and exposing them to cosmological ideas in an original way. Our quest to put the biggest questions in physics on the tip of your tongue has only just begun.

Acknowledgements

Parts of this article have been previously published on the Scientific American blog⁶.



Figure 10. Non-Euclidean Blackboard Three: The concertina used in the opening performance of the 'All There Was' show at the Institute of Contemporary Art in London. Credit: Sylvain Deleu



Figure 11. Non-Euclidean Blackboard one to four: Two pieces from the 'All There Was' show, created by David Cheeseman. Credit: Sylvain Deleu

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Notes

- 1 More information on Kitchen Theory: [@KitchenTheory](https://www.kitchen-theory.com)
- 2 More information on The Hands-On Universe project: <http://robertotrotta.com/the-hands-on-universe/> @R_Trotta @HandsOnUniverse
- 3 The "Out of this world cuisine", *PhysicsWorld* podcast is available at: <http://physicsworld.com/cws/article/multimedia/2016/jun/28/out-of-this-world-cuisine> (accessed 12.09.2017)
- 4 A video about g-ASTRONOMY for visually impaired people is available at: https://www.youtube.com/watch?v=_GEtpf1ai4o (accessed 12.09.2017)
- 5 Fatos Ustek (Ed), *Fig-2 | 50 projects in 50 weeks*, Black Dog Publishing, London (2018)
- 6 *Scientific American* blog, available at: <https://blogs.scientificamerican.com/guest-blog/where-astronomy-and-gastronomy-meet/> (accessed: Sept 12th 2017)

Box 1: The Hands-on Universe Project in Numbers

9000+ people reached in person

20+ talks in schools

100+ talks and workshops

20+ radio and TV appearances

20+ podcasts appearances

11 articles for the general public

11 literary and scientific festival appearances

4 awards

Biography

Roberto Trotta is a theoretical cosmologist at Imperial College London, UK, where he studies dark matter, dark energy and the Big Bang. He is also the Director of Imperial's Centre for Languages, Culture and Communication. Roberto is a passionate science communicator and the recipient of numerous awards for his research, outreach and art and science collaborations, including the Lord Kelvin Award of the British Association for the Advancement of Science and the Michelson Prize of Case Western Reserve University. His award-winning first book for the public, 'The Edge of the Sky: All you need to know about the All-There-Is', endeavours to explain the Universe using only the 1000 most common words in the English language. Roberto was named as one of the 100 Global Thinkers 2014 by Foreign Policy, for 'junking astronomy jargon'.