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Demarcating Fringe Science for Policy

Harry Collins, Andrew Bartlett and Luis Reyes-Galindo[1]

Introduction

Fringe science has been an important topic since the start of the revolution in the social studies of science that occurred in the early 1970s. The revolution was what Collins and Evans (2002) refer to as the 'second wave of science studies' while this paper is best thought of as an exercise in 'third wave science studies.' The first wave was that period which reached its apogee in the aftermath of the Second World War when science was seen as unquestionably the pre-eminent form of knowledge-making, and the role of philosophy and sociology was to understand how it was so and how societies could be arranged to nurture it best; the second wave was 'social constructionism' which became folded into post-modernism in general and saw all forms of knowledge making as epistemologically equal; the third wave accepts the rich model of science associated with the second wave, but grants science a pre-eminent position in virtue of the expertise and integrity of its practitioners (Collins and Evans 2002, 2007, 2017).

As a softer-edged model of the sciences developed under the second wave, fringe science became a 'hard case' on which to hammer out the idea that scientific truth was whatever came to count as scientific truth: scientific truth emerged from social closure. The job of those studying fringe science was to recapture the world view of its proponents, showing how, in terms of the procedures of science, they *could* be right and the mainstream *could* be wrong and therefore the consensus position is formed by social agreement.[2]

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[1] This paper is joint work by researchers supported by two grants: ESRC to Harry Collins, (RES/K006401/1) £277,184, *What is scientific consensus for policy? Heartlands and hinterlands of physics* (2014-2016); British Academy Post-Doctoral Fellowship to Luis Reyes-Galindo, (PF130024) £223,732, *The social boundaries of scientific knowledge: a case study of 'green' Open Access* (2013-2016). The second of these projects was initially based on the thinking that inspired the first. Andrew Bartlett was the full-time researcher on the first project. Interviews with Paul Ginsparg and most of the research on arXiv and viXra were conducted by Reyes-Galindo; nearly all the ongoing fieldwork on the 'beyond-arXiv' fringe was conducted by Bartlett. The paper has been greatly improved following discussion at the weekly seminar of the Centre for the Study of Knowledge, Expertise and Science (KES)

[2] We now know how to reconstruct the rationality of any scientific claim, including some that have long been excluded in the unfolding of science's history. We know how to show that given different social contexts, phlogiston would still be a possibility, N-rays could be revived, tobacco might be safe to smoke, the Michelson-Morley experiment would be seen as flawed, the theory of relativity could be wrong, and it would not be impossible to accept the existence of a fifth force that would make the paranormal normal. See Chang (2012) for phlogiston, though Kusch (2014) has developed a detailed criticism of his argument. For N-Rays see Ashmore (1993) and

One outcome of this way of thinking is that sociologists of science informed by second wave find themselves short of argumentative resources for demarcating science from non-science. In so far as the second wave demarcates, it is all a matter of what people *count as* mainstream and fringe – how these categories are constructed – with the inherent qualities of the science having no role to play. The distinction with traditional philosophy of science, which readily demarcates fringe subjects such as parapsychology by referring to their 'irrationality' or some such, is marked.[3] For the sociologist of scientific knowledge, that kind of demarcation comprises a retrospective drawing on what is found within the scientific community. In contrast, the second wave perspective explains why a multiplicity of conflicting views on the same topic, each with its own scientific justification, can coexist and apparent demarcations are 'social constructs'. In sympathy with the second wave we take it that many of the fringe physicists we discuss here want to do science better, *as they see it*.

A position that can emerge from the second wave perspective is to argue for less authoritarian control of new scientific initiatives – for a loosening of the controls on the restrictive side of what Kuhn (1959, 1977) called 'the essential tension'. The essential tension is the interplay between those who believe that science can only progress within consensual 'ways of going on' which restrict the range of questions that can be asked, the ways of asking and answering them and the kinds of criticism that it is legitimate to offer – often referred to as working within 'paradigms' – and those who believe that this kind of control is unacceptably authoritarian and that good science is always maximally creative and has no bounds in these respects. This tension is central to what we argue here and gives rise to one of a number of *sociological* demarcation criteria which do refer to the inherent social qualities of the science. We discuss differences in forms of life, rather than matters of rationality and irrationality. In particular, we note that fringe science often leans markedly toward the role of individual initiative and away from the constraints of a paradigm. That is an example of the kind of demarcation principle which we will set out.

The question we address is essentially a policy question even though the cases we will deal with do not involve obvious matters of direct policy significance. We are asking how decision-makers can make choices given the multiplicity of conflicting views that are found within science itself.

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see Ashmore (1996) for a discussion of the tobacco issue. For the Michelson-Morley experiment and relativity in general, see Collins and Pinch (1998) and for the paranormal see Collins and Pinch (1979, 1982).

[3] A recent collection that attempted to revisit the problem of demarcation is Pigliucci and Boudry's *Philosophy of Pseudoscience* (2013), contains, in its introduction the line "we purposefully steered clear from the kind of sociology inspired by social constructivism and postmodernism – which we regard as a type of pseudodiscipline in its own right" (p4). Not surprisingly, the section of the book titled 'The History and Sociology of Pseudoscience' was light on any serious, contemporary sociology. See also Van Rillaer (1991) and Park (2000) for typical scientist/skeptic rationalist accounts of 'mistaken' and 'irrational' science and of 'pseudoscience'. The current paper, in contrast, takes the insights of Science Studies seriously.

The problem is similar to what Collins and Evans (2002) called 'the problem of extension', which is to do with demarcation of the use of the term 'expert'.

Consider the recent detection of gravitational waves (Abbott, B. P. *et al.* 2016, 'Observation of Gravitational Waves from a Binary Black Hole Merger' *Physical Review Letters*, 116, 061102)[4]: While the mainstream scientific community exhibited a quite remarkable consensus over the soundness of the detection, within days there were criticisms and alternative interpretations emerging from the fringe including a lively blog promulgated by *Nature* and at least two full papers on the 'alternative' physics pre-print server 'viXra' (viXra:1603.0127; viXra:1603.0232).[5] Mainstream scientists mostly ignore arguments far-removed from the mainstream such as these, but to know what to take seriously and what to ignore requires that one understand the way the scientific community works – one must possess what we call 'Domain Specific Discrimination' ('Domain Discrimination' for short) which is a component of specialist tacit knowledge.[6] But what are sociologists working under the prescriptions of Wave 2 of science studies to make of these alternative claims and, more to the point as far as this paper is concerned, what is to be made of them by those who run funding agencies? After all, if the alternative accounts are correct, then the roughly billion dollars spent on the detection of gravitational waves has been wasted and the next billion being demanded to exploit the discovery and develop a new gravitational wave astronomy would be wasted too. What will happen, of course, is that the funders and other policy-makers will follow the lead of the mainstream but it surely behoves social analysts of science to say something more about the relationship between the mainstream and the fringe, not just leave things to work out as they will. We believe that it is proper in democratic societies for policy-makers and other decision-makers to begin their technological decision-making work from the consensus of the mainstream, but we want to do a better job of saying what this means. We propose that the analytical framework offered here can be a tool for defending scientific consensus on issues of grave importance, in an era when it is not uncommon to hear, for example, climate change denial being promulgated by conservative spokespersons, lobbyists and important political figures as "the mere opinions of experts". In this, our position is markedly different to recent 'interventionist' accounts in social studies of science, which begin their analysis by attempting to bring dissenting voices into controversial subjects where there is a dominant technical consensus.[7]

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[4] A book length account of this discovery will be published as Collins (2017) in February.

[5] See below for more on viXra

[6] For specialist tacit knowledge see Collins and Evans, 2007; for Domain Specific Discrimination see Collins and Weinel (2011).

[7] See Martin (2016) and other papers in that same volume, and the response by Zuiderent-Jerak (2016) based on a critique by Becker (1967). Becker highlights the inherent bias in a sociology of knowledge that favours 'the view of underdog' by examining only the elements of dissent in a hiererchical knowledge structure, particularly in studies of deviance and controversy.

Here we try to begin a program of research that will lead to a better understanding of the relationship between mainstream and fringe and, since we want our theory to be general, not tied to specific policy questions such as the safety of tobacco or global warming where the right way to jump is 'over-determined', we will concentrate on problems without an immediate health or welfare policy relevance beyond questions of funding – a kind of 'hard case'. We will look at physics, though we also must point out that it is only a historical accident that the physics we look at has, for the moment, no immediate policy relevance; controversies in physics have more than once been linked to matters of the highest levels of national and global security in the not-distant past (e.g. MacKenzie 1998, Slayton 2013).

Where the fringe begins

The fringe of physics begins at a wide and indistinct border.[8] Central to contemporary physics' activities is the 'arXiv' preprint server. arXiv, which was founded with an open philosophy, has had to close access by instituting a series of controls over who can post and by setting up a 'general physics' category into which it can divert submissions that do not fit easily into its aim of being a resource for professionals rather than a debating forum or blog. One source of problems for arXiv is what we can refer to as the 'marshy ground', the part of physics that blurs (and often contests) the boundary between what is *clearly* 'normal' science and what is *clearly* considered non-science by a research community. As an example of marshy ground physics, during long periods the topic of 'foundations of quantum theory' was not thought of as belonging to respectable physics, with calculations and applications based upon measurements being taken to be the only appropriate way to move forward while the peculiar and counter-commonsensical interpretations were to be ignored. David Bohm and other 'mainstream' physicists were discounted or wrongly dismissed by refereed journals within physics (Pinch 1977). These areas are also the focus of David Kaiser's 2011 book *How the Hippies Saved Physics* and his claim that the work of this quasi-fringe turned out to be of great value to such well-regarded modern subfields such as quantum computing and cryptography.

Growing in respectability, this area has, nevertheless, given rise to some of the most heated border disputes around postings on arXiv and the topic in some cases reaches out to fields like parapsychology, with heterodox physicists developing theories based on the interaction between the physical world and consciousness which can be said to be justified by interpretations of quantum theory. This marshy ground overlaps with what we can think of as the fringe proper with certain institutions, whose names can be found in the second line of Table 1, below, occupying an ambivalent position.

Physics thus has a long history of dealing with the problem of the fringe; though it must still draw boundaries, physics is also relatively tolerant of maverick ideas (Kaiser 2011). Of the inner end of the physics fringe, Michael Berry, former editor of the *Proceedings of the Royal Society* remarked:

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[8] Delborne (2008) has proposed five 'key boundaries' in science to understand dissent science, two of which are relevant to our analysis (see below).

> With a journal of such prestige we get a lot of junk, people who aren't scientists with a new theory. Often retired engineers seem to be prone to this grandiosity. You instantly know if a paper is junk, but on the other hand you have to take into account that the author is serious, and has thought a great deal about what they've done.[9]

Physicists have tried to resolve the problem themselves by characterising the special nature of fringe science: Baez (1998), Siegel (2011) and 't Hooft (2003) are attempts to define outsiders by adopting a waggish, 'jokey' style, perhaps to relieve the stress of the surgical exercise when they cannot be sure to the standards of logic that the 'organs' being discarded are not healthy;[10] Langmuir (1989) is more serious.[11] The sociological criteria we put forward here are meant to improve on these by taking into account the findings of Wave Two of science studies

The hinterlands of science

The 'hinterlands' of physics proper begin beyond the marshy ground even though they have a presence within it and within arXiv's General Physics category (Reyes-Galindo 2016, Ritson 2016). Papers accepted in General Physics will be indistinguishable from other scientific papers in terms of their appearance and style but the same will apply to nearly all of those rejected entirely by arXiv. Many such rejected papers will also be published in 'fringe' journals, or 'alternative' publication outlets.

The areas from General Physics outward are represented in Table 1 with Table 2 representing fringe outlets. Table 1 starts with arXiv's General Physics authors while, with some exceptions, the lower regions are more remote areas of the fringe (the left-right dimension having no significance). The second line of Table 1 shows organisations that are closest to the mainstream and occupy the marshy areas of foundations of quantum theory between the 'solid earth' of

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[9] Interview by Luis Reyes-Galindo, 6 April, 2010. Martin Gardner (1957, p. 8), well-known *Scientific American* columnist and arch-sceptic of all things unorthodox, wrote about the 'illegitimate' world of physics as full of 'stupid, ignorant, almost illiterate men who confine their activities to sending 'crank letters' to prominent scientists', but acknowledged that others are 'brilliant and well-educated, often with an excellent understanding of the branch of science in which they are speculating.'

[10] See Becker et al (1961). A less benevolent reading is suggested by Thérèse & Martin (2010) who point out that this style of satirical 'public shaming' exercises are examples of 'degradation rituals' familiar to sociologists.

[11] The normal process of socialisation into a profession, of course, brings with it a tacit sense of what is to be taken seriously. When forced to reflect, gravitational wave scientists provided Collins (2014) with the following justifications for ignoring a published paper which questioned the basis of their work: tacit aspects of style; never heard of the journal; never heard of the author; never come across this article or similar by this author; author has little record of scientific accomplishment; journal and paper are incestuous in terms of author list and citation pattern; typical cranky anti-relativity paper and anti-relativity is past its sell-by date.

mainstream physics and the 'water' of the fringe with parapsychology mostly considered, by those on solid ground, to be entirely liquid. Parapsychology – that is 'scientific parapsychology' as practised in universities and the like – is included in this row because some consider that it has an overlap with foundations of quantum theory. The next row indicates organisations beyond the marshy area though many of those who inhabit this row will, at one time, have published in arXiv and mainstream journals and/or arXiv's General Physics category. The next rows are self-explanatory. There is some degree of internal sociometric connection within the top three rows but occupants of the remaining three rows are mostly disconnected. The shaded areas of Table 1 are fringe areas other than physics but we include them here to complete our classification of ways of being in the fringe and to indicate one direction in which future research on this topic will go. As already seen with parapsychology, the division between physics and non-physics is not sharp.

arXiv General Physics population			
Fundamental Fysiks Group	Noetic Advanced Studies Institute	Institute for Noetic Studies	Parapsychology
Natural Philosophy Alliance	Society for Interdisciplinary Studies	The Thunderbolts Project	Telesio-Galilei Academy
Natural Philosophy Society	Institute for Basic Research	Alpha Institute of Advanced Study	Common Sense Science
Creationism and intelligent design	Tobacco and oil lobby	Astrology	
Fringe archaeology and other fringe sciences			

Table 1: Fringe institutions

Table 2 shows most of the outlets where the occupants of Table 1 promulgate their ideas. For example, the paper discussed in Collins (2014) was published in one of the journals in line 2 of Table 2. General Physics, individual blogs and green ink letters – letters usually exhibiting unusual graphological or typographical conventions often sent to prominent scientist expressing a maverick theory of the universe or the like – appear on both tables as they are themselves outlets while also indicating locations in the terrain of the fringe.

arXiv General Physics			
Vixra	*Progress in Physics*	*Galilean Electrodynamics*	*Apeiron*
Vigier Symposia Proceedings	*General Science Journal*	*The Hadronic Journal*	*Parapsychology journals*
Individual blogs	*Green ink letters*	*Popular books*	*Newspapers*

Table 2: Fringe outlets

Figure 2 shows extracts from some of the kinds of materials mentioned in Tables 1 and 2.

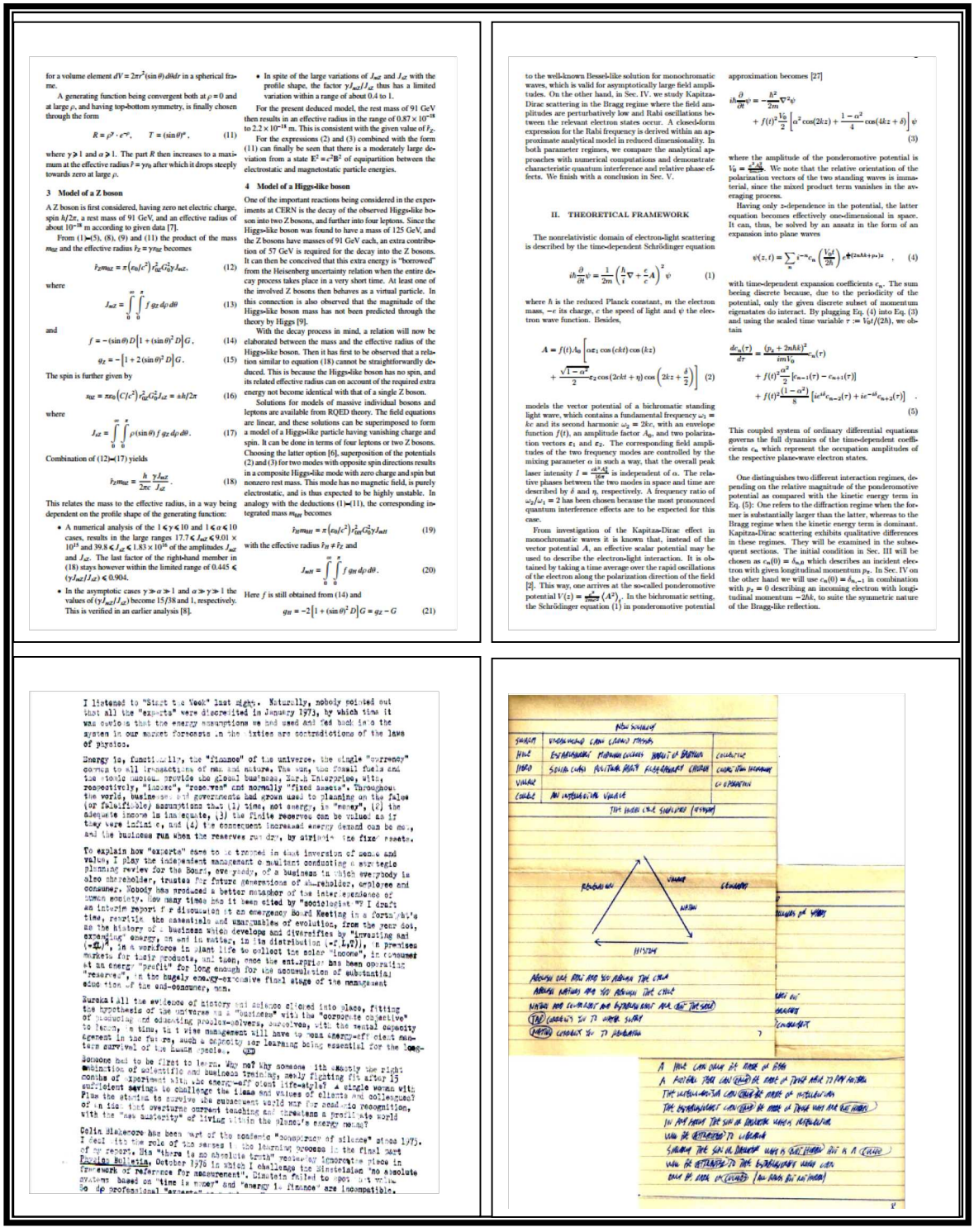

Figure 2: Extracts from paper in arXiv, a paper in a fringe physics journal (not necessarily in that order) and two 'green ink letters'[12]

[12] These materials are presented for their style not their content – they are meant to illustrate what such items look like – e.g. note similarity in mathematical content in the first two papers. Though the letters are addressed to an individual, we take them to be public documents intended

The fringe as a community

Much of the exploration of the communities of fringe physics was conducted by Bartlett. As well as an exploration of the overlapping internet-based aspects of these communities, his research included 17 semi-structured interviews with active participants in fringe physics – including those with leading organisational roles – based in the UK, USA, and Australia, and ethnographic observation at fringe physics conferences. The interviews covered topics including the participants' scientific biography – their training, career, inspirations – their engagement with mainstream scientific institutions, and their participation in the organised fringe communities. The conferences observed were the 2014 Natural Philosophy Alliance (NPA) conference in Baltimore, the 2015 Electric Universe conference in Phoenix, and the 2015 John Chappell Natural Philosophy Society (CNPS) conference held at Florida Atlantic University in Boca Raton. At the NPA conference Bartlett delivered a short presentation on the sociology of science and the nature of the research being conducted. At the Electric Universe conference Bartlett presented a paper and chaired a panel discussion involving Thunderbolts Project founders Walt Thornhill and David Talbott, Gary Schwartz, a Professor at the University of Arizona who conducts research on the survival of consciousness after death, and Michael Shermer, founder of The Skeptics Society. At the CNPS conference Bartlett gave the John Chappell memorial lecture, entitled 'The Sociology of Science– Consensus and Controversies' and was a participant in a panel discussion on 'Science, Society, and Consensus'.

The extent of the activities discussed here can be glimpsed from the 'World Science Database', now the 'Natural Philosophers Database' (NPD) associated with the Natural Philosophy Alliance and the breakaway Natural Philosophy Society (Table 1, row 3, left, and see below). The mission of the NPD 'is to catalogue all dissident science work world-wide in one place'.[13] In late summer 2014 there were 2290 people listed on the NPD, with 790 different interests listed on their profiles. The most common interests are: 'Relativity' (249), 'new energy' (211), 'gravity' (164), 'aether' (108 people), 'electric universe' (99), 'antigravity' (92), 'expanding Earth' (81) and 'cold fusion' (65).

Though we are going to treat the entries in Table 1 and Table 2 individually, a large proportion of the fringe has characteristics of a distinctive community. Members will often meet at the same conferences and organisers are interconnected. For example, Cynthia Kolb Whitney was the president of the Natural Philosophy Alliance (NPA) and editor of *Galilean Electrodynamics*, while William Lucas, who was the NPA vice-president, is also a scientist with Common Sense Science. Francesco Fucilla, the 'founding father' of the Telesio-Galilei Academy of Science (TGA) (which began as the Santilli-Galilei Academy, Ruggero Santilli being founder of the Institute of Basic Research), is also a fellow of the Noetic Advanced Studies Institute (NASI). NASI fellow Elizabeth Rauscher was a founder of the Fundamental Fysiks Group. Myron Evans, who heads the Alpha Institute for Advanced Studies (AIAS), helped establish the Vigier Symposia, which are

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to be promulgated (there will typically be many recipients). We understand them as intended in the spirit of letters to one's MP or Congressperson, or letters to a newspaper.

[13] "Natural Philosophers Database", URL: http://db.naturalphilosophy.org/

now sponsored by NASI, while NASI founding director Richard Amoroso is also listed as member of the AIAS. The NPA's Sagnac Award has been given to Halton Arp (late editor of Apeiron) and Donald Scott, both luminaries among 'Electric Universe' theorists, while the TGA has awarded Gold Medals to, for example, Myron Evans and Wallace Thornhill, who is one of the founders of The Thunderbolts Project.

The sense of community, fragile though it may be, is also indicated by certain common characteristics not shared by mainstream science; we now describe three of these. We stress that we are *not* describing *these* characteristics as a way of marking off the fringe as a distinct socio-cognitive community – that exercise will come later. It is also vital to stress that these three characteristics only capture a proportion of the scientists and institutions described here. For example, a number are physicists still in mainstream jobs that would be horrified to find themselves associated with those observed during fieldwork who put forward Jewish conspiracy theories.

Firstly, and unsurprisingly, the typical age of a contributor to the fringe seems to be considerably higher than that of contributors to mainstream science. According to the NPD, the average age of those in the database is 65.1[14] and when Bartlett attended the 2014 NPA conference he was, at 37, by some margin the youngest presenter. By contrast, McWhinnie (2013) in a survey for the Institute of Physics, found that average age of permanent academic staff in the UK is 44.7 for men and 40.6 for women, not including contract researchers, who tend to be younger. Retired scientists with time to do unorthodox and unpaid work and whose career would no longer be put at risk by thinking outside the mainstream box seem to make up a disproportionate element of the community.

Secondly, there is a surprising readiness to discuss the possibility that the resistance of the mainstream to fringe ideas is the consequence of mainstream cabals, particularly, a Jewish conspiracy. The website scientificethics.org, makes allegations of 'Jewish corruption' and 'scientific gangsterism'[15] as a cause of the 'persecut[ion] of the Italian American scientist R. M. Santilli', leading to the suppression of unorthodox scientific ideas, particularly those that conflict with 'organized Jewish interests on Einstein'.[16] A previous PhD research project at Cardiff on the danger of genetically manipulated organisms also ran into Jewish conspiracy theories when fringe ideas were rejected. Ethnographic research reveals that a casual, 'matter-of-fact', conversation can be held over dinner in certain fringe organizations about Einstein's one-time support for Israel

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[14] "Natural Philosophers Database > Birthdays", URL: http://db.naturalphilosophy.org/birthdays/

[15] "Some of the scientific gangerisms perpoetrated[sic] by the Jewish physicist Steven Weinberg", URL: http://www.scientificethics.org/Steven-Weinberg.htm.

[16] "Documentation of Jewish Dishonesty and Corruption on Prof. Santilli's Article at Wikipedia", URL: http://www.scientificethics.org/Wikipedia-corruption.htm. This website comes very close to being anti-Semitic, for example explaining Hitler's actions by reference to the controlling influence of Jews in Germany.

leading the large number of Jews in modern physics to support relativity against all opposition. This is an uncomfortable echo of the 'Jewish physics' notions of the Nazis.[17] We wrote to a number of senior mainstream physicists asking if this kind of accusation ever reached their ears but they told us that this was no part of day-to-day physics nor had they ever heard of such things. Clearly this kind of idea violates the Mertonian norm of 'universality' and this might be said to distinguish at least a proportion of the group from the socio-cognitive activity of mainstream science. We will see that 'norm-violation' is one of our demarcation characteristics. But since much of the fringe does adhere to the Mertonian and other typically scientific norms, and since a proportion of the mainstream violates the norms, norm violation will be a useful criterion for policy-makers on only rare and specific occasions.[18]

Thirdly, there are a large number of engineers, particularly electrical engineers, populating the fringe. For example, of the 31 speakers at the EU2014 conference organized by the Thunderbolts Project, at least 11 had backgrounds in engineering, 5 of which were electrical engineers. This was also noted by Michael Berry, who remarked that he thought engineers' views were based in a 'practical working knowledge and a sound intuitive understanding of aspects of electromagnetism' but this, he believed, could make it hard to accept the counterintuitive consequences of a relativistic world view. Physicists and engineers are two different cultural groups, differently educated, but dealing successfully with the same phenomenon. The two traditions clash head-on only very rarely as in the case of the development of GPS. Here is how it looks from the viewpoint of a member of the one of the fringe groups:

> Fringe physicist: [T]here are quite a few with engineering backgrounds in the NPA. ... I think this has to do with engineers being more pragmatic, and not attached to any particular ideology. Particularly in theoretical physics, much of the "standard" science is based on a set of shared assumptions ... or perhaps the better word is "dogma". Engineers are typically practical people, who use science and apply it to the real world. Since their careers are not anchored to these dogma, they don't have any problems questioning the Big Bang [for example]. Another example is when the first GPS satellites went up, all the engineers thought Einstein's concept of warped space-time was nonsense. It turns out that some of these engineers became believers since the Einstein-based adjustments proved to work. However, some engineers and scientists in the NPA have demonstrated that Lorentz transformations work equally well for GPS satellite adjustments.... I also have a background in electrical engineering. I look for new physics which I can apply. And when I come across any physics, my ultimate arbitrator is "can I build something with this, or can I verify it through experiment". I won't be able to build an anti-gravity machine based on current physics. I also won't be able to build a device for superluminal (faster than the speed of light) communications which according to Einstein, would be

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[17] In 1938, *Nature* published an anti-Jewish-physics letter from an institutionally powerful German Professor of physics (Stark 1938). See also Wazeck (2014).

[18] The norms are explored in greater depth in a work on the relationship between science and society (Collins and Evans, 2017, *Why Democracies Need Science*,).

> impossible. But I don't really care what Einstein said … My career does not depend on whether I am an Einstein "believer" or not.[19]

Analytic description of the hinterlands of science

We now show how the institutions and outlets listed in Tables 1 and 2 differ as socio-cognitive enterprises from mainstream science in terms of, among other things, 'formative intentions' (Collins and Kusch 1998). Formative intentions are what drive the actions that that members of cultural groups aspire to and which give rise to their characteristic 'form of life' (Winch 1958; Wittgenstein 1953) – taking out mortgages in some societies, divining witches in others, and so forth. Our demarcation criteria turn, in part, on distinguishing the formative intentions characteristic of the fringe from those that characterise the mainstream.

We organise the discussion of different institutions under eight characteristics. Two of these characteristics represent the default position of mainstream science: the coherence and authority on the one hand, and the individualism on the other, that *together* constitute 'the essential tension'. The other six characteristics are discussed under separate sub-heads. Three of the six differences we will draw out come from previous work and three are new.[20] The discussion works roughly from-out-to-in, in terms of the geography of the fringe. The schema is set out in Table 3, where the characteristics are found in the top row numbered 1-8 with exemplifying activities in the left hand column. A shaded square indicates that the corresponding activity is characterised by the label in the top row. The presence of shaded squares in columns 3 onwards indicates differences with mainstream science. A square with a heavy border but no shading indicates that the activity may or may not exhibit the characteristic. The top-left to bottom-right direction corresponds roughly to distinctiveness from mainstream science. We work through the characteristics and will then go back and classify the institutions that have not already been used as examples.

Oblique Orientation

The first difference between certain fringe activities and mainstream science is *oblique orientation* (column 8). Indeed, it is not clear if activities thus characterised should be counted as candidates for the label 'science' in the first place. Astrology, the typical activity presented, aims to appeal to the public rather than other scientists. Fringe archaeology – supposed remnants associated with Arthurian legends and the like – also fits here because it is directed more at providing material for popular books than at impacting on the science of archaeology. Perhaps something similar could be said for the works of Erich von Daniken and other books positing past cosmic catastrophes or

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[19] E-mail communication to Bartlett 30th January 2015.

[20] In this kind of analysis, which deals with family resemblance rather than necessary and sufficient conditions, boundaries are fuzzy and the way we assign activities into them can never be exact. .

visits from aliens and the like. Conspiracy theories – 'the Moon landings were faked; corpses of aliens can be found at Roswell' – are also not intended to be absorbed into mainstream science.

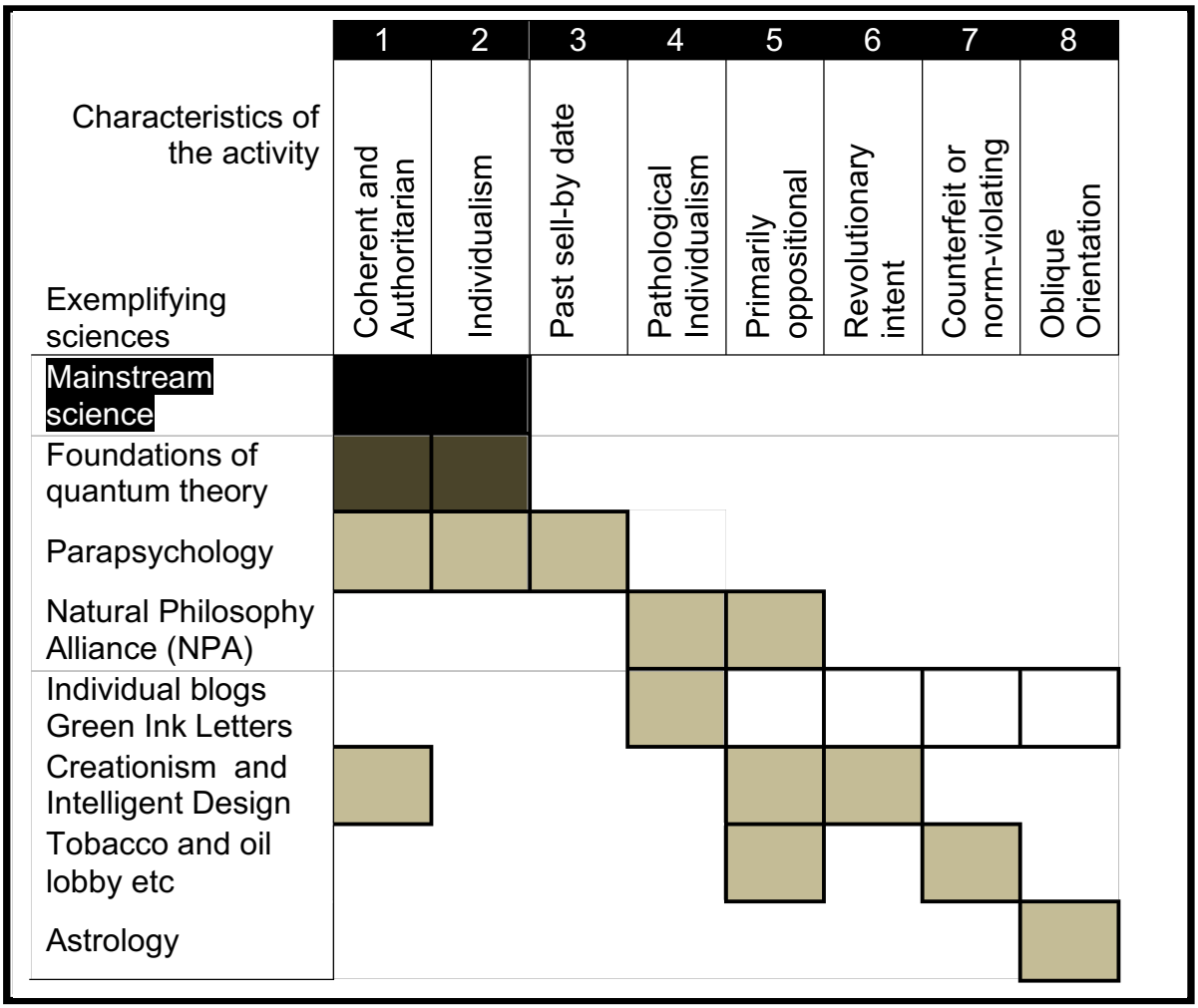

Table 3: Ways of being on the fringe of science

Norm-violation

Column 7 represents *norm-violation* (eg. Mertonian norms) by which we mean the so-called 'research' purchased by the tobacco and oil lobbies so as to fabricate doubt and create 'counterfeit scientific controversies'.[21] Jewish-conspiracy theories would also fit here but not in a policy-useful way.

Revolutionary Intent

The next outermost characteristic (column 6) is *revolutionary intent*. Collins and Evans (2007) claim that for something to be counted as science – say, Joe Weber's defeated gravitational wave claims (Collins 2004) – the author of the claim should be aiming to preserve as much of existing

[21] Oreskes and Conway (2010); Collins and Weinel (2011).

science as possible. If the work is revolutionary its protagonists should be *reluctant revolutionaries* aiming to change as few concepts, empirical assumptions and experimental procedures as possible.[22] This does not mean that anyone who wants to modify the institutions of science is consigned to the fringe since we know that some of the institutions, such as peer review, do not work very well (Smith 2006). To make this idea work we need to be ready to separate the essential, defining, characteristics of science as a form of life – the formative intentions -- from the less essential ones.[23] What is being referred to as revolutionary intent are attempts at radical transformation of the nature of science – such as changing the balance between the value of old books as compared to observation and experiment, or looking to the general public for acclaim and verification of research findings rather than fellow experts, or looking at radical cognitive change such as over-turning the second law of thermodynamics. Thus, though Einstein engendered a revolution in our understanding of space and time, and Joseph Weber could have given rise to a revolution if his findings had been believed and interpreted in certain ways (a revolution and a proto-revolution in the Kuhnian sense), this was not their authors' primary intent. Einstein and Weber wanted to preserve the existing observational nature of science. Max Planck was also a reluctant revolutionary who to his last days tried to reconcile the new physics he paved the way for with classical physics (Kragh 2000). Should it be felt that there is a scientific case for even something as radical as the overthrow of the second law of thermodynamics, it would be done with greatest reluctance. Creationism and intelligent design, in contrast, start with a shift in the order of what counts as evidence, not to square certain observations with the rest of science, but to make a special place for divine intervention when it comes to observation-based claims.[24] The formative intentions of creationism therefore differ from those of mainstream science in a marked way and this puts us in a position to say to policy-makers: 'in respect of understanding scientific consensus, you can ignore any claims arising out of *creationism* because they are not claims arising out of an institution that is continuous with science even though their proponents direct them toward science.'

Sell-by-date

Columns 4 and 5 are central to the fringe and we will look at column 3 before returning to them. For a claim to be 'past its sell-by date' means that science as a social organisation has allowed any controversy associated with the claim to drift out of focus, even though it was once a topic of hot debate in the mainstream.[25] The proponents of the now ignored idea are likely to be able to point out that it has not been thoroughly defeated by logic or observation and refuse to

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[22] The same demarcation criterion was put forth by Lakatos (1978).

[23] For a brief attempt to make such a distinction see Collins (2011/2013, 153ff) and also Collins and Evans (2017).

[24] Though intelligent design appears to work independently of old and obscure books, its unfalsifiable hypothesis which leads to no new avenues of research would not be posited without the influence of such sources.

[25] Collins and Weinel (2011).

accept the past sell-by date characterisation. Parapsychology, that is to say, 'scientific parapsychology', as conducted in university departments and the like, with its careful, statistically-analysed experiments and peer-reviewed journals, is indistinguishable from mainstream science in terms of the eight characteristics except that it has been making claims for so long without any breakthrough success that it has ceased to be a matter of concern to the mainstream. It is now mainly criticised by philosophers, stage-magicians and the amateurish 'skeptics' movement rather than by scientists.[26] The difficulty with this category is that all anti-relativity movements, for example, could also be said to be past their sell-by date as the principal opposition to the theory of relativity faded away some decades past. We choose to treat these movements as primarily oppositional, however, reserving the sell-by-date criterion for movements which are not essentially oppositional: parapsychology is not against anything but, rather, wants to add an extra dimension to existing science. Elsewhere we applied the concept to unorthodox theories of HIV. These have a more oppositional character but it could be said that this is not the principal motivation but a consequence of the alternative view.[27]

Primarily Oppositional and Pathological Individualism

Returning to column 5, *primarily oppositional*, indicates opposition to mainstream science as the main organising principle of the activity. The prime goal of those pursuing such an enterprise is not to advance science but to oppose certain of the findings of existing science – for example, the category includes those whose main aim is to find flaws in the theory of relativity. Of course, 'organised scepticism' is a feature of regular science but this refers to specific results rather than the totality of a mainstream field.

Being primarily oppositional also tends to be closely related to *pathological individualism* (column 4), which refers back to the essential tension. We take it to be a characteristic of science as we know it that there is always a tension between authority and coherence on the one hand and individual brilliance and heterodox discovery on the other. In fact, in terms of the categories listed in Table 3, the essential tension, along with the absence of characteristics 3-8, is what defines mainstream science. As we can see, under this scheme, the 'marshy ground' of quantum foundations counts as mainstream science even though many of its practitioners have found themselves pushed into arXiv's General Physics category or have been excluded from arXiv altogether.[28] Pathological individualism is exhibited when the *main concern* is with individual, heterodox, brilliance without any recognition that it has to be in tension with collective coherence and authority. This is *pathological* individualism, absence from column 1 implying

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[26] The notion of sell-by-date could, with a stretch, be said to have a resonance with Langmuir's (1989), 'The ratio of supporters to critics rises up to somewhere near 50% and then falls gradually to oblivion,' though Langmuir does not see the phenomenon as sociological.

[27] Weinel (2007, 2010).

[28] Which is simply to say that here demarcation criteria are more subtle.

presence in column 4. Green Ink letters and individual blogs exhibit pathological individualism because they are independent of peer review or community assessment before promulgation.[29]

Fringe organisations

We now turn to describing some of the fringe organisations to illustrate how the above categories appear in practice. The Natural Philosophy Alliance (NPA) is one of the most active, diverse, and well populated organisations on the fringe and is a paradigm of pathological individualism and oppositional stance. A statement by one of its leaders sums up its approach:

> Instead of trying to play the consensus game ... we're going to be like everything else: in [the] arts, could you imagine if everyone paints the same? ... Consensus is not only wrong, but detrimental and dangerous. It keeps us from true scientific progress. (David de Hilster at the 19th Annual Natural Philosophy Alliance Conference, 2012, Albuquerque, NM.[30])

Since this group exhibits this characteristic so clearly, we will spend some time describing it and its close relations. Formed in 1994, by summer 2014 the NPA claimed just over 130 paid-up members and more than 800 'members' on its website, though in summer 2014 the NPA split, with a two organisations emerging, the Natural Philosophy Alliance and the John Chappell Natural Philosophy Society (NPS)[31]. While the organising committees and other administrative organs of these two associations are in conflict, there is significant overlap in membership. Neither the NPA or the NPS have their own journal, but publish the proceedings of its annual conference electronically and in print using self-publication services such as Lulu. They also provides links to electronic versions of the papers of 'members' (not always with their consent or foreknowledge).[32] The NPA has organised 21 Annual Conferences (the most recent organised by the post-split NPA, with the NPS holding its inaugural conference in August 2015). Running over several days, they draw in a wide range of fringe physicists and include the presentation of

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[29] An example of extreme but non-pathological individualism was mathematician Grigori Perelman's unexpected posting on arXiv of the critical missing steps to prove the Poincaré conjecture, which had eluded the world's greatest mathematicians. The proof was not submitted for peer review by Perelman, although it was later verified by mathematicians. Perelman retired from mathematics and declined the prizes and honours associated with the proof, including the 1 million dollar Clay Millennium Prize and the Fields Medal. By posting on the arXiv, however, Perelman (already a highly respected mathematician who was one of the prime candidates for proving the conjecture at that point) ensured that the international mathematical community would scrutinise his work.

[30] Video available at "Consensus in Science is Wrong", URL: https://youtu.be/UABe5oiYUCU

[31] "John Chappell Natural Philosophy Society > About", URL: http://www.naturalphilosophy.org/site/about/

[32] As reported to Bartlett during fieldwork.

the 'Sagnac Award'. The *Proceedings* for the 2013 Annual Conference, the last before the split, run to nearly 400 pages. Even the diminished, post-split 2014 NPA Annual Conference, at which Bartlett presented a paper and conducted ethnographic observation, attracted delegates from the UK, Australia, Colombia, New Zealand, and Russia. Of the 23 presenters listed on the programme, at least nine have doctoral-level degrees in physics or a related subject, with a handful holding academic positions in universities.

The Natural Philosophy Alliance and the John Chappell National Philosophy Society adopt some characteristics of mainstream scientific institutions such as awards, organised meetings, etc., but they also differ in crucial respects. On the one hand the these organisations sometimes appear to be 'science orientated', as illustrated when a speaker at the 2014 NPA Annual Conference presented material that implied support for 'Young Earth' Creationism[33]. In a heated e-mail exchange immediately after the conference, several members of the NPA voiced objections on the basis that this was non-scientific in that it was derived from a reading of the Bible rather than observation and experiment. On the other hand, these organisations espouse a strongly individualistic model of science that makes such boundary work difficult. Theres is also some flavour of revolutionary intent: 'The NPA wants to change the current philosophy of science and return to the ancient Greek approach to natural philosophy based on the logical approach of the axiomatic method.'

The NPA and the NPS are therefore primarily organised around its opposition to mainstream physics. The pre-split NPA webpage listed the problems of contemporary science: 'The Big Bang theory is fundamentally flawed […] Relativity has flawed assumption and when proof for such is examined, it is not proof at all […] Expansion tectonics (the earth is expanding / growing) is a much better model than modern-day plate tectonics […] The universe is way more electrical than currently thought […] Most all NPA scientists agree that science took a huge wrong turn in the early part of the 20th century'.[34] In the literature of the NPA we also find a perfect expression of pathological individualism:

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[33] While there are several flavours of creationism, Young Earth Creationism is the religious belief that the Earth was created mere thousands of years ago (typically about 6000) by God. While this is by no means a popular idea on the fringes of physics examined in this paper, several theories espoused by fringe physicists – for example the idea that the speed of light and other constants have been slowing - have been deployed to support an Earth much younger than is held by mainstream science. Some of this work has touched on the institutional 'marshy ground' – see, for example Norman and Setterfield (1987) *The Atomic Constants, Light and Time*, an invited report published by Stanford Research Institute (which was, among other things, an institutional refuge for members of the Fundamental Fysiks Group) and Flinders University in Australia.

[34] "Problems in Mainstream Science", URL: https://web.archive.org/web/20130729040741/http://www.worldnpa.org/site/problems-in-mainstream-science/

> Following the words of Galileo "In questions of science, the authority of a thousand is not worth the humble reasoning of a single individual", the NPA does not accept any authorities in science except logic and empirical data. Science is not a democratic process. Just as the world would have benefited from listening to the words of Galileo during his lifetime, the NPA champions the right and necessity of all natural philosophers to be given a fair hearing based on the logical and experimental basis of their work instead of its "political correctness" under the current philosophy of science.[35]

Inasmuch as these organisations hold a model of science, it is that progress comes through the iconoclasm of individuals overturning stale orthodoxies:

> We value free expression and vigorous debate of scientific thought; and we reject the assertion that scientific validity may be established through consensus[36]

These are ideal expressions of one side of the essential tension; that the authority of coherence of belief and consensus is, by its very nature, suspect:

> **Science in the mainstream is dominated by politics, not science.** Criticism of Einstein, the big bang, and other mainstream theories is not allowed in the mainstream whereas in all other human endeavours including music, art, literature, business, politics and engineering, opposing ideas are necessary for coming up with the best solutions humans can muster. The NPA encourages diverse opinion, believing that better truths will emerge.
>
> **Most all NPA scientists agree that science took a huge wrong-turn in the early part of the 20th century.** Many NPA members independently and collectively are starting physics and cosmology over from the time of Einstein in 1905 in order to put science back on track.[37] [original emphases]

The result of this kind of approach to science is reflected in the cognitive and social life of the fringe as a whole in that organisations are continually splitting and reforming with bitter disputes turning on the sets of ideas of individuals; many of the organisations are associated with named individuals in a way that the organisations of mainstream science are not. The phenomenon was observed within the organisations by Bartlett during the 2014 NPA conference in Baltimore and the 2015 NPS conference in Boca Raton. Both were, on the face of it, scientific conferences, but they were loosely organised administratively – at times very disorganised – and without cognitive

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[35] "Principles of the Natural Philosophy Alliance" URL: http://worldnpa.org/about/principles/

[36]" Mission Statement", URL: https://web.archive.org/web/20130801162841/http://www.worldnpa.org/site/mission-statement/

[37] "Problems in Mainstream Science", URL: https://web.archive.org/web/20130729040741/http://www.worldnpa.org/site/problems-in-mainstream-science/

coherence. The delegates were brought together by their opposition to the mainstream, with each delegate expressing their opposition in their own terms – an expanding earth, an electric universe, an eternal and evolving universe. The NPA and NPS conferences were a space for the presentation of any number of different ways of being in opposition to the mainstream. The tendency to schism among the organisations and the administrative disorganisation is a nice example of homology between cognitive and administrative organisation. Each of the scientists, cherishing individuality, distrusts authority and organisation. Any residual unity is not brought about by sharing a common goal other than to be against the mainstream. Members of the organisation themselves recognise the problem:

> The alternative to the mainstream has not been organised. So what you find is most of them start off believing the mainstream, they fall out of the mainstream, and they think they've got something new to revolutionise physics. So they all come away believing they're the new Einstein. So they're the ones forming part of the NPA. Everybody talks to each other, they've got their own pet theories, but they're not going to get organised around one theory because they're all promoting their own pet theory. And that's what the mainstream has created. It's disorganised the alternative. The alternative to the mainstream has not been able to organise, because the voice has been silenced.[38]

This degree of individualism has to be 'pathological' because the NPA's claim – 'the NPA does not accept any authorities in science except logic and empirical data'— would imply that no-one else's observations or calculations could be ever trusted. In this scenario, science as we know it would grind to a halt – trust goes with social organisation and social coherence. We can, then, advise policy-makers: if a group is driven primarily by opposition to the mainstream then there are grounds for taking their views less seriously.

Remaining institutions

We now provide brief sketches of the remaining institutions, indicating which of the characteristic they share and where they would fit on Table 3. These remaining institutions will be found in rows 2 and 3 of Table 1 and row 2 of Table 2.

The Thunderbolts Project was founded in 2004 to promote the Electric Universe (EU) paradigm, which 'emphasizes the role of electricity in space and shows the negligible contribution of gravity in cosmic events.'[39] The Thunderbolts Project holds annual conferences and publishes books and DVDs through Mikimar Press. As with the *Society for Interdisciplinary Studies* (below), there is a strong Velikovskian strain to their membership, and the contribution of electrical engineers is evident.[40] Bartlett participated in the EU2015 – Paths of Discovery conference in Phoenix.

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[38] Bartlett, interview with fringe scientsts, 26th June 2014.

[39] "Exploring the Electric Universe", URL: https://www.thunderbolts.info/wp/about/syn/

[40] Immanuel Velikovsky began a movement based on maverick theories about the ancient past set out in his book *Worlds in Collision*.

These annual conferences have grown to quite large events, with over 200 attendees and a similar number subscribing to a live stream of the presentations. Unlike the NPA and the NPS, *The Thunderbolts Project* avoids pathological individualism because of the unity of its ideas. One illustration of this is the attendance at EU conferences of an *audience* comprising many non-presenting attendees. Another is the development of a collaborative experimental programme into the 'electric sun' hypothesis, supported with funding from the International Science Foundation[41]. The emphasis on historical and mythic records of catastrophe, popular books, and the insights of non-scientists seems to place the organisation in the following columns: 8, because it has an element of oblique orientation; 6, because if successful it would precipitate an institutional revolution in science; and, perhaps, 5, because opposition is a strong driving force.

The Society for Interdisciplinary Studies was founded in 1974, another organisation inspired by Immanuel Velikovsky. The SIS straddles fringe archaeology and fringe physics. Presenters at their meetings discuss catastrophist interpretations of pre-history alongside ideas such as the Electric Universe. Evidence of ancient catastrophes play a central role in their work and they claim that '[many] great discoveries and insights are made by intuitive non-scientists'.[42] The analysis of this group in terms of characteristics is similar to that of *The Thunderbolts Project* (above).

Founded in 2008, the *Telesio-Galilei Academy of Science* is not overtly oppositional, but 'champions the true scientific spirit, promoting 'courageous departures from conventional perceptions', citing Copernicus, Newton and Einstein.[43] The Annual Gold Medals that it awards in this spirit are, most often, given to fringe physicists. It is certainly characterised by pathological individualism as Galileo's name in its title indicates. Galileo is a frequently recurring motif in the fringe.

The Institute for Basic Research was founded in 1981 by Ruggero Santilli to promote his 'Hadronic Mechanics'. The IBR listed its membership at 135 in 2008, claimed 'scientific addresses' six countries, and controls the Hadronic Press, which publishes two journals and a number of monographs. The substance of the IBR's program is more directed at a Kuhnian rather than an institutional revolution but the readiness with which it's supporters endorse the idea of a Jewish conspiracy could class it as having revolutionary intent and being norm violating.

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[41] SAFIRE (Stellar Atmospheric Function in Regulation Experiment) appears to be the only project currently supported by the International Science Foundation (ISF), Funding for SAFIRE is described in this way: "Through private funding, ISF offered $1,000,000 for its initial financing with $1,200,000 for continued funding through 2015". "SAFIRE Project", URL: http://isciencefoundation.org/safire/

[42] "SIS Background", URL: http://www.sis-group.org.uk/sis-background.htm

[43] "Telesio - Galilei Academy's Mission", URL: http://www.telesio-galilei.com/tg/index.php/missions-and-goals

Its strong leadership style suggests pathological individualism and an emphasis on opposition to mainstream science.

The *Alpha Institute for Advanced Study* was founded in 1998 to promote Myron Evans' Einstein-Cartan-Evans (ECE) theory – a Unified Field Theory, which refutes, 'in great detail' '[n]early all the precepts of standard physics'.[44] The AIAS claims 38 named 'fellows' in addition to Evans. The AIAS expressly rejects standard forms of scientific dissemination, preferring self-publication on the AIAS website claiming that journal publication is obsolete and restrictive while the web allows measures of actual usage to indicate significance.[45] It is therefore pathologically individualistic, and primarily oppositional as well as having revolutionary intent in terms its views on publication.

Common Sense Science is a small group, seemingly based around three or four physicists and or electrical engineers who publish a newsletter and journal, *Foundations of Science*, along with privately distributed books and videos. They pursue a physics that reflects the 'Judeo-Christian Worldview' and are opposed to 'quantum reality, randomness, and multiplicity of force laws'.[46] CSS seems unified but they also seem primarily oppositional and, given the central role that religion plays in their cognitive lives and institutional activities, they appear to have revolutionary intent.

Remaining outlets

We now move to row 2 of Table 2, the outlets that correspond to the institutions described above,

viXra (arXiv spelled backwards) is an electronic preprint server founded in 2005, by Phil Gibbs, a former physicist. viXra has over 10,000 papers in its archive, and claims to be 'truly open', accepting all submissions except those that are 'vulgar, libellous, plagiaristic or dangerously misleading'.[47] viXra was founded in reaction to arXiv's rejection of various classes of papers, has revolutionary implications in respect of publication practices in science and tends to encourage or at least allow an outlet for pathological individualism.[48]

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[44] "Alpha Institute for Advanced Studies (AIAS)", URL: http://www.aias.us/

[45] "Overview of ECE Theory", URL: http://www.aias.us/index.php?goto=showPageByTitle&pageTitle=Overview_of_ECE_Theory

[46] "Worldview Principles", URL: http://www.commonsensescience.org/worldview_principles.html

[47] "Why viXra?", URL: http://vixra.org/why

[48] Phil Gibbs interviewed by Reyes-Galindo, 11 November 2014.

Founded in 2005, *Progress in Physics* promotes 'individual academic freedom and will consider all work without regard to affiliations'.[49] It published a Declaration of Academic Freedom[50], arguing that peer review had become a tool of censorship so it has revolutionary intent and encourages pathological individualism though the papers it publishes have all the appearance of scientific papers so it does not operate without any constraints.

Apeiron, published between 1987 and 2012, was closely associated with Halton Arp, a critic of Big Bang Theory. The editorial board was made up of scientists and mathematicians holding academic positions, but published work from fringe physicists associated with the NPA, and the TGA. We do not know enough about *Apeiron* to classify it with confidence.

Galilean Electrodynamics (GED) is a journal, founded in 1989 by Petr Beckmann (d. 1993), a professor of Electrical Engineering, to promote his anti-relativity position. The current editor is Cynthia Kolb Whitney, vice-president of the NPA. The journal is avowedly oppositional, describing itself as 'devoted to publishing high quality scientific papers, refereed by professional scientists, that are critical of Special Relativity, General Relativity, Quantum Mechanics, Big Bang theory and other establishment doctrines.'[51]

The *Vigier Symposia* have been running since 2005. The Vigier Symposia are sponsored by the Noetic Advanced Studies Institute, an institution located in the 'marshy ground'. The symposia are well embedded in the fringe of physics, with, for example, Telesio Galileo Academic gold medals awarded alongside the symposia in 2010 and the 2014 symposia being well attended by Natural Philosophy Alliance members. Scientists with current academic positions also present at these conferences, however, and the proceedings have been published by such mainstream publishers as the American Institute of Physics, Springer, and World Scientific. Therefore the Vigier Symposia seems to straddle the marshy ground.

The *General Science Journal*, while starting as a home for criticisms of Special Relativity, provides an outlet for pathological individualism as well as implying revolutionary intent in respect of publication practices. The journal sees itself as, 'provid[ing] an opportunity for public presentation of scientific theories without prior and arbitrary assessment, criticism or rejection by the recipient. Judgement by the few runs counter to the spirit of scientific exploration' [52]

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[49] "Progress in Physics", URL: http://www.ptep-online.com/

[50] "Declaration of Academic Freedom", URL: http://www.ptep-online.com/index_files/rights.html

[51] "Galilean Electrodynamics", URL: http://web.archive.org/web/20151002140914/http://home.comcast.net/~adring/

[52] "Dedicated to the Free Expression of Scientific Theories", URL: http://gsjournal.net/Science-Journal/purpose

Conclusion

In this paper we have asked and tried to answer a question that has arisen out of the revolution in the social studies of science that took place in the 1970s (and has been referred to as 'the second wave of science studies'). We look at problems for social scientists and decision-makers that arise out of the proscription on simply drawing on scientists' authority when it comes to judgments of scientific truth. We have proposed sociological ways to understand the difference between mainstream and fringe science and described differences in the form of life of the mainstream and the fringe. Science studies should be able to enrich, legitimate and possibly qualify the demarcation process already used by scientists. We have offered a number of analysts' demarcation criteria based on the form of life of science, a paradigmatic example being a difference in the balance of 'the essential tension' in the case of the fringe compared to the mainstream. What we believe we have done is make a start on a science studies programme that could provide a better understanding of the relationship between science and technological decision-making that is based on a social understanding of the institution of science and the essential tension.[53] A more difficult task will be to extend this kind of analysis to what we have called 'the marshy ground.'

We also address a question that has long puzzled the authors: what is the model of science that informs the writers of green-ink letters and other members of the fringe? The answer is one in which isolated individuals are often best placed to plumb the secrets of nature while consensus is dangerously authoritative. It is an idealised, a-social, model of science. Strangely, it appears as if science's idealised model of itself as a kind of logical machine is precisely what gives rise to the fringe; many members of the fringe believe they are the only true upholders of this asocial model. Strangely, to the extent to which science studies scholars see their role as supporting the claims of the fringe and including them in a levelled out science, they are promulgating the very individualistic model of science which the 1970s revolution was supposed to have done away with.

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[53] See also Collins and Evans 2017

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