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Challenging Dominant Physics Paradigms

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Abstract—There are many well-qualified scientists who question long-established physics theories even when paradigms are not in crisis. Challenging scientific orthodoxy is difficult because most scientists are educated and work within current paradigms and have little career incentive to examine unconventional ideas. Dissidence is a strategic site for learning about the dynamics of science. Dozens of well-qualified scientists who challenge dominant physics paradigms were contacted to determine how they try to overcome resistance to their ideas. Some such challengers obtain funding in the usual ways; others tap unconventional sources or use their own funds. For publishing, many challengers use alternative journals and attend conferences dedicated to alternative viewpoints; publishing on the web is of special importance. Only a few physics dissidents come under attack, probably because they have not achieved enough prominence to be seen as a threat. Physics could benefit from greater openness to challenges; one way to promote this is to expose students to unconventional views.

Keywords: physics—paradigms—challengers—alternatives—orthodoxy

Physics has a reputation as one of the most highly developed and well established fields of science. Although there are many exotic-sounding theories at the research frontier involving strings, black holes and charm, the basic postulates of classic theories such as electrodynamics, relativity and quantum theory are seen as solidly established.

It is surprising to find, therefore, that there are many challengers to orthodox physics who offer critiques of conventional theories and present their own alternative formulations. Furthermore, many of these challengers are well qualified, with degrees, mainstream publications, positions at well-known universities and prizes including the Nobel Prize. Table 1 gives a few examples, listing only a selection of these particular challengers' achievements. This is not a ranking of dissidents; there are others with just as many accomplishments.

If you decide to question a widely accepted theory, or to present data that is anomalous in terms of current understandings, it can be difficult to gain a hearing. Although the essence of scientific advance is going beyond current knowledge or offering a new way of understanding data, questioning fundamentals is seldom welcome. Some types of challenge, such as perpetual motion machines or causality violation, are automatically rejected. Others, such as cold fusion, are openly considered and tested but then, if they do not measure up, henceforth rejected by mainstream science.

It is easy to dismiss challengers as "cranks," but this risks rejecting fresh ideas from those who are well placed to achieve radical breakthroughs. There are instances where the official expert view is later revealed as unproductively dogmatic, as when the French Academy rejected observations by common people of stones falling from the sky. It may be that "the kinship of the scientific crank with the scientific creator is more than a superficial one" (Watson 1938, 41) but few scientists embrace this connection.

A proponent of an unorthodox idea is likely to encounter several types of difficulties. First, it is difficult to obtain funding: very few research grants are awarded for proposals to re-examine long accepted theories. Most funding agencies expect that proposals will build on existing science rather than challenge basic postulates. Second, it is difficult to publish in mainstream journals. Third, proponents of unorthodoxy may come under attack: their colleagues may shun them, they may be blocked from jobs or promotions, lab space may be withdrawn and malicious rumors spread about them. Even if they can overcome these problems, they have a hard time gaining attention.

Our focus here is on strategies used by challengers to overcome such obstacles. In the next section we outline ideas from the social studies of science that help to explain the way science responds to challenges. Then, drawing on responses to questions we submitted to dozens of physics dissidents, we look at methods used by challengers to current paradigms to obtain funds for research, publish their work and survive attacks. We conclude with some observations about how challenges to orthodoxy, even though most of them are judged wrong, can be used constructively.

Understanding Challenges

Of the large body of research in the history, philosophy, psychology and sociology of science, we here pick out a few key ideas that are helpful for understanding why challenges to orthodoxy are likely to be given a cold reception. We have found that some earlier ideas, now superseded in the eyes of many, remain useful for explaining challenges and responses, though for other purposes these same ideas have important limitations.

The most common view about how science works is that new ideas are judged on the basis of evidence and logic: if a new idea explains more data or provides more precise agreement with experiment, this counts strongly in its favor.

Karl Popper claimed that science advances by falsification (Popper 1963). In his view, it is the duty of scientists to attempt to disprove theories, confronting

TABLE 1
A Sample of Well-Qualified Challengers to Orthodox Physics

Halton Arp is a professional astronomer who has worked at the Mt. Palomar and Mt. Wilson observatories. He has received the Helen B. Warner prize, the Newcomb Cleveland award and the Alexander von Humboldt Senior Scientist Award. He has published a large amount of evidence that contradicts the big bang (Arp 1987, 1998).
Andre Assis is professor of physics at the University of Campinas, Brazil, is the author of several books and over 50 scholarly articles and is a leading authority on Weber's electrodynamics. He is a critic of relativity (Assis 1994, 1999).
Robert G. Jahn is professor of aerospace science and dean emeritus of the School of Engineering and Applied Science at Princeton University and has received the Curtis W. McGraw Research Award of the American Society of Engineering Education. He researches mind-matter interactions.
Paul Marmet was professor of physics at Laval University, Québec, for over 20 years, is author of over 100 papers in electron microscopy, was president of the Canadian Association of Physicists and has received the Order of Canada. He is a critic of relativity.
Domina Eberle Spencer is professor of mathematics at the University of Connecticut and has published several books and over 200 scholarly articles. She supports an alternative theory of electrodynamics, in the Gaussian-Weberian-Ritzian tradition.
Tom Van Flandern has a PhD in astronomy from Yale University, became chief of the Celestial Mechanics Branch of the US Naval Observatory and received a prize from the Gravity Research Foundation. He is critic of theories of the big bang, gravity and the solar system (Van Flandern 1993).

them with experimental data and rejecting them if they do not explain the data. Theories that cannot be falsified are, according to Popper, not scientific. Many scientists believe in falsificationism.

These conventional views were challenged by Thomas Kuhn (1970). Kuhn argued that scientists—and physicists in particular, since most of his historical examples were from physics—adhere to a paradigm, which is a set of assumptions and standard practices for undertaking research. If an experiment gives results contradictory to theory, then instead of rejecting the theory altogether, alternative responses include rejecting the experiment as untrustworthy and modifying the theory to account for the new results (Chia 1998; Chinn and Brewer 1993).

When anomalies accumulate, the paradigm can enter a state of crisis and be ripe for overthrow by a new paradigm. This process of scientific revolution does not proceed solely according to a rational procedure but involves social factors such as belief systems and political arrangements. Kuhn's successors have modified his model of paradigms and revolutions, for example showing that paradigms are not as well defined and incommensurable as Kuhn imagined, but they have extended his insight that the process of scientific change involves social factors and is not just a rational matter (Barnes 1977, 1982; Collins 1985; Fuller 2000; Mulkay 1979; Pinch 1986).

In any case, the idea of paradigms puts a different spin on the problem of new ideas in science. Rather than being dealt with according to logic and evidence, challenging ideas may be ignored or rejected out of hand because they conflict with current models. In effect, the logic and evidence used to establish the paradigm are treated as definitive and are unquestioningly preferred over any *new* logic and evidence offered that challenge the paradigm. During periods of "normal science," the ideas developed by mainstream scientists originate *from* current paradigms: they add more and more pieces to standard puzzles. Given that the paradigm is the source of ideas, it is not surprising that challenges to the paradigm—the framework that allowed mainstream scientists to contribute to the development of science—are seldom greeted with open arms. If a theory is not considered physically plausible, it may be rejected even though it makes successful predictions (Brush 1990).

Eminent philosopher of science Imre Lakatos says that research programs have a hard core set of fundamental principles surrounded by a set of subsidiary, less significant assumptions, called the protective belt. For the research program to advance, lesser assumptions can be tested and possibly modified, protecting the hard core from being falsified (Chalmers 1999, 130–136; Lakatos 1970).

Conventional science education helps to perpetuate current orthodoxy. Students are introduced to physics through textbooks that typically present current ideas as "the truth" and either ignore alternative ideas altogether or portray them as convincingly disproved by experiment. Students learn by solving problems, and the concepts and magnitudes used in these problems assume the validity of current theories. Only rarely are students presented with theories that don't work, and even in those cases, such as Bohr's model of the hydrogen atom, the intent is to show how researchers overcame problems. By and large, students are confronted only with success in science. Acceptance of received wisdom is deeper because orthodoxy is never discussed as orthodoxy: it is simply the truth. Students are also taught about the "scientific method"—observation, hypothesis formulation, testing, etc.—and hence come to believe that theories that have been tested by experiments are true, because the textbook scientific method is thought to be the way science actually operates. Views that science actually proceeds in a different fashion are seldom mentioned (Barnes 1974; Bauer 1992; Feyerabend 1975). Relevant here is a famous quote from Max Planck (1949, 33–34): "A new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is familiar with it."

The system of examinations and degrees is a sorting process; the physics PhD screens out most of those who question orthodoxy (Schmidt 2000). Once students are committed to the basic principles of the field, then it is possible to begin research and to question, within implicit limits, prevailing ideas.

There are definite advantages to training and researching within a standard framework. Rather than spending lots of time getting bogged down in the basics, researchers instead can move more rapidly and confidently to the cutting edge, pushing out to unexplored areas of knowledge and, thus, reinforcing and developing the paradigm. As long as the basic principles of the field are sound, it makes sense to simply learn them and build on them. Traditional education seldom tells students how to go about challenging current paradigms.

There is another obstacle facing challengers: the psychological commitment of scientists to current ideas, especially their own ideas and the dominant ideas. The usual image of the scientist is of a cool, calm, detached, objective observer, but the reality is quite different (Mahoney 1976; Mitroff 1974), as anyone who knows scientists is aware. The classic study of the psychology of scientists is Ian Mitroff's book *The Subjective Side of Science*, in which he revealed that Apollo moon scientists were strikingly committed to their ideas, so much so that contrary evidence seemed to have little influence on their views. As well, scientists express strong views, often quite derogatory, about other scientists. To expect every scientist to react coolly and objectively to a competitor's idea is wishful thinking, though there are some scientists who approach the ideal. Intriguingly, Mitroff found that it was often the top scientists who were the most strongly committed to their ideas.

Tom Van Flandern commented to us:

> I have taken aside several colleagues whose pet theories are now mainstream doctrine, and asked quizzically what it would mean to them personally if an alternative idea ultimately prevailed. To my initial shock (I was naïve enough that I did not see this coming), to a person, the individuals I asked said they would leave the field and do something else for a living. Their egos, the adulation they enjoy, and the satisfaction that they were doing something important with their lives, would be threatened by such a development. As I pondered this, it struck me that their vested interests ran even deeper than if they just had a financial stake in the outcome (which, of course, they do because of grants and promotions). So a challenger with a replacement idea would be naïve to see the process as anything less than threatening the careers of some now-very-important people, who cannot be expected to welcome that development regardless of its merit. (1 August 2002)

Though it is easy to criticize dogmatism, a certain amount of it can be valuable for scientific progress. That was certainly Kuhn's view: unless the current paradigm was in crisis, dogmatism in science education and practice has a functional value (Kuhn 1963). Michael Polanyi, a chemist and eminent commentator on science, argued "that the scientific method is, and must be, disciplined by an orthodoxy which can permit only a limited degree of dissent, and that such dissent is fraught with grave risks to the dissenter" (Polanyi 1963, 1013). Similarly, Mitroff concluded that the classic norms of science, such as universalism, disinterestedness, communism and organized skepticism, did not adequately explain the operation of science, and instead proposed that counternorms were equally important, including "organized dogmatism."

Another problem facing challengers stems from the intense pressures under which most scientists work. Many scientists, especially those who are ambitious, work extremely hard. They may spend long hours in the lab or in problem-solving on top of other duties such as teaching, supervision and administration, not to mention life outside of work. Science is highly competitive and even the most talented scientists need to work hard to stay ahead of the game.

What happens when some challengers, who have spent years or decades developing their ideas, show up and ask a busy career scientist for an assessment? Even for an open-minded or sympathetic scientist, it is a real sacrifice to spend days or even just hours examining alternative ideas, since that means correspondingly less time available for their own pressing work. The more eminent scientists serve as editors and referees for prestigious journals where they typically are focused on rejecting work that *fails* to meet the standards of orthodox science, making it even more difficult for them to accept work that *challenges* those standards.

Most challengers believe their ideas have value, otherwise they would not bother with them. What they desire from mainstream scientists is not acceptance (though that would be nice!) but a fair-minded examination of their ideas. There is a certain irony here: challengers confront academic power and what some of them see as corruption, but what they really desire is the attention of mainstream scientists. The practical problem facing challengers is a scarcity of attention: there are not enough scientists who have both the time and inclination to scrutinize their unorthodox ideas.

The way that science is organized exacerbates the problem of shortage of attention for paradigm challengers. Most scientists work as part of a small network, local and/or international, members of which address the same topic, share common interests and goals, exchange information and reprints, and attend the same conferences (Crane 1972). Scientists are more likely to devote attention to work by others in their network than they are to the work of outsiders. Dissidents who go to the roots of a paradigm do not specialize sufficiently to be part of such a network: they are outsiders in the field in the sense that they do not focus on a small portion of a paradigm. As a result, few scientists will be willing to give them any attention.

In summary, perspectives and evidence from the history, philosophy, psychology, and sociology of science, and from science education, suggest that the obstacles facing challengers are formidable. Most scientists, due to their education and day-to-day interactions, work within the prevailing paradigm. Most scientists develop a strong commitment to their own ideas, a psychological process that is reinforced by the large career investment in a particular line of work. Finally, the competitive struggle for success means that most scientists are extremely busy, with little time available to examine unconventional ideas.

There is, though, a contrary force: the rewards available for significant innovation. The founders of quantum theory and, above all, Einstein as the founder of relativity theory are heroes in physics for inaugurating new paradigms. Even short of these epic feats, physicists may aspire to be known for their contributions, which often means questioning the received wisdom.

Choosing research problems can be likened to an investment process (Bourdieu 1975, 1988). Scientists have available a certain amount of "capital"—knowledge, experience, time and effort—that they can invest in different ways.

A conservative investment strategy is to pursue small, incremental innovations, with a high likelihood of success and a modest return on investment, following Peter Medawar's dictum that science is "the art of the soluble" (Medawar 1967). A risky strategy is to pursue a speculative idea: the likelihood of success may be low but the returns, if the idea pans out, can be huge. For example, astrophysicist Fred Hoyle could be said to have originally invested in the steady-state theory of the universe, which had decent prospects but turned out to be a bad bet. He later made a riskier investment in the more speculative "life-in-space" hypothesis (Hoyle and Wickramasinghe 1978) which, if validated, would have more dramatic returns (though now too late for Hoyle). In a sense, paradigm challengers are ambitious investors, in that they commonly criticize entire theories, such as relativity and quantum theory, rather than just a part of such theories. They seek to change theories at the level of university textbooks.

A different investment calculation comes into play, though, when it comes to someone else's ideas. To examine or even promote someone else's challenge to orthodoxy requires significant time and energy, yet the major returns go to the other person, if they are recognized as the innovator. If the idea is a promising one, the temptation is to grab credit, for example by domesticating the radical idea and publishing in orthodox journals. It is no surprise that many innovators are afraid of having their ideas stolen.

So although there is an incentive to pursue unorthodox ideas, only some researchers will be tempted to do so. The obstacles remain daunting, especially given that paradigm-challenging ideas are seldom taken seriously. Furthermore, few will have the eminence of a Hoyle to attract attention to their ideas.

Investigating Dissent in Physics

Our aim is to gain insight into how challengers can overcome the obstacles facing them. We began our empirical investigation by examining a range of work—including our own—on resistance to scientific innovation (Barber 1961; Bauer 1984; Campanario 1993a, 1993b, 1995, 1996, 1997, 2004; Mauskopf 1979; Nissani 1995; Sommer 2001) and suppression of dissent (Hess 1992; Horrobin 1990; Martin 1981, 1996, 1998, 1999a, 1999b, 2004; Moran 1998). From the large array of obstacles facing challengers, we concluded that three areas are of crucial importance: obtaining funding, getting published, and dealing with attacks. Though there are other types of obstacles, we focus on these three since our interest is less in obstacles than on ways of overcoming them.

By examining a diverse set of challenges, we came up with a list of ways of overcoming these obstacles. (See Table 2.)

To determine which of these methods are actually used in physics, we obtained the addresses of a sample of dissidents by means of webpages of journals such as the *Journal of Scientific Exploration* and meetings and societies of dissidents. To exclude most of the many uninformed and unsophisticated critics, we restricted our attention to those who have scientific degrees or are affiliated with reputable

TABLE 2
Some Methods That Challengers Can Use to Overcome Barriers to Their Work

1. Funding
- A. Obtain funding from innovative agencies.
- B. Obtain funding from agencies not worried about the innovative aspects.
- C. Obtain private funding.
- D. Fund the research through personal resources.
- E. Apply political pressure to obtain funding.
- F. Use conventional funding but disguise the nature of the research.

2. Publishing
- A. Challenge the editor's rejection.
- B. Use friends or patrons to help get published.
- C. Submit to other journals.
- D. Publish in many different journals and conferences.
- E. Keep publishing after the initial breakthrough.
- F. Seek wider audiences beyond the key discipline.
- G. Set up a journal or a special section in an established journal; attend alternative conferences.
- H. Send out preprints.
- I. Publish books.
- J. Publish paid advertisements.
- K. Seek coverage in the mass media.

3. Surviving attack
- A. Continue without being distracted or discouraged.
- B. Seek support from others who have come under attack.
- C. Expose the existence of attacks, especially their unscientific aspects.
- D. Expose the bias or vested interests of the attackers.
- E. Seek support from colleagues or a professional association.
- F. Counterattack using similar methods.
- G. Take legal action.
- H. Join with others who have come under attack.

universities or have publications in mainstream journals, though no doubt this restriction excludes some worthy challengers. Given our aim of finding a diverse group satisfying our criteria—namely that they are challengers to dominant physics paradigms who have scientific degrees or research positions or publications—our search was extensive but not exhaustive.

We did not attempt ourselves to judge the quality of the dissidents' work. Whatever our own ideas about some research work's rigor, agreement between theory and experiment, quality of expression and the like, others would be likely to differ in their assessments, especially because judgments about quality are commonly mixed with views about whether conclusions are right or wrong. Hence, rather than use personal assessments in our selection process, we relied on the surrogate measures of degrees, affiliations and publications, which encapsulate the collective judgments of other scientists.

We wrote to a total of 41 well-qualified dissident scientists, mostly in physics, inviting them to describe their experiences in overcoming resistance to new ideas in science. We drew their attention to our list of methods (Table 2) but invited them to tell about any other methods that they had used. We obtained many fascinating responses, some of which are mentioned below. We did not seek to collect statistical data on use of different dissident strategies, because our aim was exploratory; responses to our letters were wide-ranging, suggesting the limitations of imposing neat classifications at this stage. Not enough is yet known about dissident strategies to make it worthwhile pursuing quantitative categorization, especially given that self-reports may reflect different judgments about matters such as success and failure of a strategy.

Because our aim was to find out how contemporary challengers try to overcome obstacles, we ruled out those who were once dissidents but subsequently succeeded in obtaining recognition. There are a number of these who could be cited (Hook 2002; Hunt 1983), of which one of the most prominent is S. Chandresekar (1969), whose ideas on stellar evolution were initially rejected by Sir Arthur Eddington and others. Examination of such cases suggests that most dissidents encounter the same sorts of obstacles whether they are ultimately vindicated or not.

How to Mount a Challenge

Although we asked about experiences in *overcoming* resistance, many respondents focused more on the resistance itself, commenting critically on the nature of the scientific establishment. For example, Paul Marmet said that "Scientists prefer to stick to old theories even if they do not make sense. I was at first very surprised by that reaction but, after a few years, I had to admit that it is a normal human reaction" (28 July 2002). Ruggero Maria Santilli, president of the Institute for Basic Research, said "There simply is no way of correcting academic-scientific corruption and I consider futile any attempt at that" (4 August 2002). According to Bruce Harvey, a dissident physicist, "To say that the established scientific world is prejudiced against new ideas is an understatement. It is paranoid about them." (13 August 2002).

On the other hand, some respondents believed that, despite resistance, in the long run their ideas would be recognized. David Bergman said that "Nevertheless, I am confident that the truth will come out and Common Sense Science will prevail as valid science. I have no ideas how long it will take, or how many will come to accept the scientific truth that modern physics must be replaced (not reformed)." (30 July 2002).

Funding

Innovators often have a hard time obtaining funding from conventional sources. Sometimes their funding is withdrawn. One option is to obtain a job in science—often by doing conventional research—and use it as a base to do unorthodox research. Those who are more successful using this strategy can even create a lab or institute, such as Princeton Engineering Anomalies Research, a laboratory for research on the mind-matter relationship. This option is more common for scientists who become interested in unorthodox ideas after establishing an orthodox career, as in the case of Brian Josephson, who won the Nobel Prize in physics for the discovery of the effect named after him and who is now working in parapsychology.

Sociologist Ron Westrum, who has studied the scientific community's response to anomalous phenomena (Westrum 1977, 1978), thinks that the most comfortable basis for mounting a challenge to orthodoxy is as an older or retired professor (23 October 2002). Historian-of-science Stephen G. Brush offers similar advice: obtain a secure job and do conventional research to establish a reputation, thus laying a foundation for proposing radical ideas (31 October 2002). However, these options are available to only some individuals.

Some pursue unorthodox ideas by using conventional funding but disguising the nature of the research. We are aware of a case in which astronomers, while using a major telescope for observations on a conventional research topic, used a bit of spare time at the end of their observing run to look for something different, relevant to an unorthodox theory. Richard A. Muller (1980) revealed how he circumvented the funding system for innovative (though orthodox) research. According to David Horrobin (1989), editor of *Medical Hypotheses*, scientists know that to obtain funding they must misrepresent their motivations in grant proposals, otherwise "All innovative scientists know that they would rarely get funded, such is the nature of the review system."

Parapsychology researcher Helmut Schmidt—a physicist by training—was employed by Boeing Scientific Research Laboratories when he carried out some of his early work using quantum random number generators (Schmidt 1969). (Later he worked in a private research institute.) Corporate funding has sustained cold fusion research after it was rejected by mainstream science (Simon 2002).

There are a few grant-giving bodies open to unorthodoxy, such as the Lifebridge Foundation, Money for some types of unorthodox projects is available from the military, which does not want to miss potential applications no matter how unorthodox the theory behind them.

Other challengers do not ever get started in a conventional career. They are more likely to support their work through their own funds. This helps explain why so many challengers focus on theories; personal funds are seldom sufficient to sustain a significant laboratory. Cynthia Kolb Whitney, editor of *Galilean Electrodynamics*, says that "Personal resources have worked best for me. Though resources are modest, there are no discontinuities, uncertainties, interferences, or other annoyances" (17 August 2002).

Publishing

Innovators often have a difficult time getting published. Submissions may be rejected or subjected to significant delay. Major revisions may be required. Even when published, the work may be neglected. Challengers have used a variety of methods to promote their ideas.

Sometimes unconventional papers are rejected without refereeing or any critical comment, in which case the author can request a formal assessment. Apparently *Nature* previously returned all submissions from private addresses without looking at them; one of those so treated was atmospheric scientist James Lovelock, later best known for his Gaia hypothesis (Bond 2000). Authors also can contest the comments made by journals, asking for re-evaluation. Of course, challenging the editor's rejection is a technique available to all scientists, but it is especially important when ideas may be rejected out of hand.

After a rejection, it is a standard technique to scout around to find somewhere else to publish. Challengers often have to search more widely in doing this. However, there is a down side, as indicated by Paul Marmet: "Spending too much time in an effort to publish our ideas in conventional journals leads to serious frustration. That is a trap, which destroys the delicate ability that can lead later to new ideas." (28 July 2002).

Stephen G. Brush recommends writing balanced review articles, with plenty of citations of other authors, for publication in a journal such as *Reviews of Modern Physics,* allowing the possibility of some self-citation (31 October 2002). However, we are unaware of any dissidents who have adopted this approach.

Even when challenging ideas are published, they may be ignored (Collins 1999). Therefore, publishing in a range of journals and presenting papers in a variety of conferences maximizes the chance that someone will take the ideas seriously.

Parapsychologists set up their own journals, rigorously refereed, such as *Journal of Parapsychology*—reputable enough to be included in the Science Citation Index database—to get around the low acceptance rate in mainstream journals. Other examples in physics include *Journal of Scientific Exploration, Galilean Electrodynamics, Frontier Perspectives, Infinite Energy, Cold Fusion* and *Apeiron*. Several of our respondents reported favorably on alternative journals. Vladimir Ginzburg said he "published five papers in the journals that are receptive to speculative ideas, *Speculations in Science and Technology* and *Journal of New Energy*." Caroline Thompson, who has challenged standard views on quantum entanglement, commented: "I attempted to publish my next important paper in *Physical Review Letters*. The story of its rejection is the subject of my Tangled Methods paper [Thompson 1999]. The paper in question has now been accepted by *Galilean Electrodynamics*. I have had other papers in *Infinite Energy* and the *Journal of New Energy*, and contributed chapters to a few books." (16 August 2002).

Conferences dedicated to alternative viewpoints, and conference proceedings, provide a venue for challengers. Domina Eberle Spencer, who has worked since the 1940s on reformulating electromagnetic theory, reports that as well as new journals open to discussing fundamental questions, "International meetings which welcome discussions of such questions have taken place in St. Petersburgh, Russia, Bologna, Italy, Cologne, Germany and Lanzarote, Spain. In the United States the Natural Philosophy Alliance was established in 1994 and has held annual meetings ever since." Concerning her work, "Of course, it is still not possible to have these results recognized by the established physics journals. But the situation is much better than it was." (27 July 2002).

In setting up alternative journals and conferences, dissident scientists imitate mainstream science. They may complain that orthodox science and conventional peer review reject their discoveries but they don't try to develop alternative evaluation methods. Challengers are pleased when mainstream bodies organize conferences or conference sessions oriented to unorthodox ideas.

Some book publishers are more open to challenging ideas than journals, as long as there is a market. Hoyle and Wickramasinghe found publishers for a whole series of books. Self-publishing is another option, adopted by many dissidents. Vladimir Ginzburg reports that after rejections by publishers, he self-published three books. Chris Illert (1992/1993) self-published his work on a classical model for nuclear physics.

Publishing on the web is inexpensive and offers wide accessibility. Lars Wåhlin, who has developed alternative viewpoints on gravity and relativity, says, "I believe that it is better to publish on the internet because it will be available to everybody and not only to a few journal subscribers. It can appear for an unlimited time and it has the advantage that one can make corrections at any time if necessary." (4 August 2002). Bruce Harvey writes: "Failing to get my work on electromagnetic momentum immediately recognised by the British establishment, I produced my web-site. That led to my inclusion in many lists and invitations to fringe conferences. ... I have extensive email correspondence with others in the same field. ... I think my web-site amounts to a better exposure of my ideas than most professional scientists receive." (17 August 2002). Paul Marmet says "Presently, the Web is by far the best compromise to publish new controversial ideas in science, because nobody can stop you, it is very widely distributed and it costs almost nothing." (28 July 2002). In addition, there are some internet newsgroups devoted to "alternative physics," such as the Natural Philosophy Alliance (http://mywebpages.comcast.net/Deneb/npahome.html) with its Dissident Physics Discussion Group (http://groups.yahoo.com/group/NPA_Dissidents/).

Obtaining electronic publication in credible forums can be another matter. Caroline Thompson says that she "put copies of my papers in the archive arXiv.org. I was able to do this because I have managed to arrange to have a university address. Had it been otherwise I might have found it hard to register. A contact of mine who did manage to register from a home address and submit a paper was jubilant for a day or two then found his registration cancelled and the paper withdrawn."

Another strategy is to publish a paid advertisement. For example, Pierre-Marie Robitaille (2002) paid to publish an article in the *New York Times*. Cameron Y. Rebigsol offers a $50,000 reward to anyone who can disprove his mathematical arguments against relativity (http://members.aol.com/crebigsol/awards.htm). Such individuals are anxious to have their ideas scrutinized.

Seeking coverage in the mass media is another option. The mass media are not refereed but instead operate on the basis of "news values" such as prominence, proximity, conflict, timeliness, action, human interest, and perceived consequences. A scientific controversy, especially one involving a local personality, could well be considered worthy of coverage. However, most journalists are respectful of scientific authorities, so it can be difficult for challengers to obtain sympathetic coverage. One of the best opportunities for media coverage arises when unorthodox ideas are published in mainstream journals, as in the cases of parapsychology and homeopathy. On the other hand, many scientists look down on colleagues who obtain media coverage, so this option has disadvantages for those seeking greater credibility.

Surviving Attack

Some innovators come under attack beyond normal criticism of their ideas. For example, their professional integrity may be challenged, malicious rumors may be spread about them, they may be threatened, their submissions or grant applications may be rejected without proper review, their grants may be removed, their access to facilities may be denied, and their jobs may be put in jeopardy.

Attacks are especially common when challengers provide support to a social movement opposing a powerful interest group, as in the cases of nuclear power, pesticides, and fluoridation (Martin 1999b). The most famous dissident physicist is Andrei Sakharov, known for his challenge to Soviet nuclear policy and for being a prominent scientist who was willing to speak out in a repressive society. Hugh DeWitt, a physicist at Lawrence Livermore National Laboratory who was prominent in his criticism of US nuclear weapons policy, came under attack at several points in his career. Scientists and engineers critical of nuclear power have been suppressed in many countries (Freeman 1981; Martin 1986; Sharma 1996). These nuclear critics did not challenge physics paradigms, but the techniques used against them illustrate how paradigm challengers may be attacked.

Advice for whistleblowers emphasizes collecting large amounts of documentation of the problem to be exposed, consulting with family and friends before taking action, preparing to survive attack, not relying on official channels such as ombudsmen or courts, and carefully assessing options (Devine 1997; Martin 1999c). Some of these recommendations are relevant to physics dissidents. Before openly supporting an unorthodox idea, it is wise to collect documentation of good performance in one's job, be aware that there could be repercussions, talk matters over with family and friends and not assume that grievance procedures or professional associations will provide any help against harassment or victimization. It is unwise to risk one's career without being fully informed.

The experience of whistleblowers, from a range of fields, is that talking to other whistleblowers is immensely beneficial. The existence of networks of dissident scientists suggests the value of mutual support. Although dissidents often disagree with each other's theories—for example, some accept quantum theory but challenge relativity and others do the reverse—some of them are able to work together in societies like the Natural Philosophy Alliance. On the other hand, we are aware of dissidents who are quick to dismiss other dissidents as crackpots.

Only a few of the scientists we contacted described significant problems in their careers, for example having to leave university posts, due to their dissenting views. The response of an establishment to challengers typically follows the sequence of neglect, ridicule, attack and co-optation. Most challengers remain at the first stage, being entirely ignored. If they are ridiculed or come under attack, that is a sign of some success!

Cynthia Kolb Whitney, editor of *Galilean Electrodynamics*, says to ignore attacks. "People who make them will never be convinced anyway, so don't waste energy. Dissidents like us live in a parallel universe largely separated from mainstream physics, except when the big breakthrough comes, which it certainly will do from time to time." (17 August 2002).

One of the least effective responses is counterattack. Paul Marmet told of researchers who sued those who refused to accept their new idea. One won his court case after 15 years, but "after so many years, it was too late and he was no longer able to get new ideas in physics. He was just a legal expert." (28 July 2002).

Conclusion

Challenges to orthodoxy exist even in periods of "normal science," though this is ignored by most analysts of science. Many challengers are well qualified—with degrees, positions at reputable universities, publications in mainstream journals, even Nobel prizes—but their presence remains unknown to many scientists.

The life of a dissident is seldom easy. That is certainly the message from those who challenge dominant ideas in physics. Some have persisted in the scientific wilderness for decades.

Our impression is that most challengers believe in the scientific approach—that ideas should be tested on their merits, and that those ideas that work better will be accepted—sometimes more strongly than mainstream scientists. Roger Nelson says "I believe that it is essential to do excellent work" (13 August 2002). Ruggero Maria Santilli says "My main suggestion to fight established doctrines is that of bringing new theories to the level of predicting new demonstrated effects and then establishing them experimentally" (4 August 2002). Vladimir Ginzburg is "trying a new way of presenting a new idea. This way of presenting includes: a) clear and reasonable assumptions that are based on common knowledge, b) applying the commonly known calculation methods, and c) presenting the results that can readily be verified" (24 July 2002).

Because many of the theories proposed by dissidents are comparatively simple and straightforward, they should be easier to falsify and therefore are, in Popper's framework, exemplars of good scientific theories.

The experience of challengers, though, is that they are not treated "scientifically." Instead, they are typically ignored or rejected without adequate examination. This also happens to many normal scientists but, because they are developing the paradigm, they cannot complain that unorthodoxy is the reason their work doesn't receive attention.

Collectively, challengers have tried various methods to overcome the obstacles facing them, but few individuals seem to have carefully considered a range of options, much less tried them. There are, though, a few experienced challengers with well developed assessments of the dynamics of science and strong ideas about the best way to proceed.

Some mainstream physicists think that the way the discipline now responds to new ideas is just fine: the field is progressing, so why worry about those on the fringe? Most of them are wrong, so why bother?

But there is another viewpoint: challengers, even those who are wrong, offer a potential source of strength to science. Their incessant questioning can be used to guard against complacency, to improve thinking and to prop open the door to change. One of the greatest perceived strengths of physics is its openness to speculation at the cutting edge of research. The field is not so fragile that greater openness concerning established principles is a real threat to the achievements of the field, though it may be threatening to some whose careers are built on particular findings or theories. Greater openness to challenges would increase respect for the field from potential contributors, whereas dogmatism and arrogance cause alienation.

Teachers often say to their students that they should be skeptical, not believe something until it has been tested, and so on. If students later perceive that dissidents are ignored or their theories rejected without testing, that hurts the image of science, even when the dissidents are wrong.

But what does greater openness mean? Certainly not automatic publication of any dissenting idea. If physicists want to be more open to new ideas, the key is attention: spending some time examining unorthodox ideas. One way to achieve this is to give students—such as advanced undergraduates—projects that involve theoretical assessment or experimental testing of unconventional views. This will extend students' minds. If good students cannot refute a challenge, then it might be time for attention by more experienced researchers. Other options are setting up new journals and websites for challenging ideas, and treating them seriously.

Another use of dissent, in teaching, is to show students what happens to those who challenge current theories. This should be a part of the curriculum at the university level to avoid misconceptions about how science works. It can also provide insight to dissidents who might choose, as Tom Van Flandern suggests, to "keep their heads down" so they "can survive long enough to become senior in their fields" (30 September 2002). Finally, for those who get their work published with no difficulties, studying the travails of dissidents can provide insight into what it is like for others.

Charlatans and others interested in exploiting the public's ignorance sometimes seek credibility by pointing to dogmatism in science. If scientists are seen to be open to new ideas, public confidence in science can be bolstered.

No one knows the optimum level of tolerance for new ideas in a field. This might be something worth experimenting with. Physics challengers would certainly say that, at least as regards their own ideas, tolerance needs to be increased.

Notes

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