Piccirillo, Lucio, Professor of Radio Astronomy Technology. "The Cosmos Above Me, and the Moral Maze Within Me: Astrophysics and Basic Research – Some Reflections." *Scientific Freedom: An Anthology on Freedom of Scientific Research*. Ed. Simona Giordano, John Coggon and Marco Cappato. London: Bloomsbury Academic, 2012. 42–49. Science, Ethics and Society. *Bloomsbury Collections*. Web. 26 Apr. 2023. <<http://dx.doi.org/10.5040/9781849669009.ch-003>>.

Downloaded from Bloomsbury Collections, www.bloomsburycollections.com, 26 April 2023, 15:09 UTC.

Copyright © Simona Giordano, John Coggon and Marco Cappato 2012. You may share this work for non-commercial purposes only, provided you give attribution to the copyright holder and the publisher, and provide a link to the Creative Commons licence.

3

The Cosmos Above Me, and the Moral Maze Within Me

Astrophysics and Basic Research – Some Reflections

Lucio Piccirillo

*Professor of Radio Astronomy Technology, School of Physics
and Astronomy, University of Manchester*

The discovery of a new dish confers more happiness on humanity than the discovery of a new star. (The physiology of taste. Brillat-Savarin)

Scientific discovery and scientific knowledge have been achieved only by those who have gone in pursuit of it without any practical purpose whatsoever in view. (Where is Science Going? Pt. 4. M. Planck)

Introduction

I think I belong to a privileged class of men and women who materialized their dream work. I always wanted to be an astrophysicist and I consider myself very lucky to have a University that pays me to do what I love: research and teaching. My research consists mainly in developing new instrumentation for making more and more sensitive and accurate astrophysical measurements. My teaching keeps me in contact with the new generations with their incredibly fresh minds and novel ideas. Every year the first day in class I ask the new coming students a few questions. Why did you choose to study physics? What job would you like? And a few other questions of a similar tenor. The last question that I pose is slightly different because it is somehow unexpected and usually forces the students to think on the spot. The question is: ‘Why should the government invest 30 million pounds in an astrophysics experiment instead of building a new hospital?’ At this point most of the faces turn to me with a different light in the eyes. They certainly did not expect *this* question. I am sure I triggered in their mind some ethical questions.

Is it a good thing to invest in basic science while we have people struggling with basic needs? I will not even touch the political issues involved, mostly because I feel I am not qualified. I just point out that governments set the budget destined for basic research. Scientists write proposals and apply for their research funding from a fixed pot whose content is decided by governments. Although somebody else has the authority to decide the overall budget destined for science, I still think it is not only morally acceptable to use resources for basic research but overall is one of the best ways of using time and money.

Organization of science

Before giving my reflections on the last issue above, it is important to clarify how science is organized. This will help in understanding the mechanisms involved and, ultimately, the dynamics of science. After all, science is a human endeavour aimed at understanding the world around us in an analytical way.

My personal view of the organization of science is probably different from what most non-scientists would suppose. I agree with the chemist Michael Polanyi¹ who looked into the mechanisms of scientific research. He described a ‘republic of science’ composed of free men and women not bound by any limitation of race, origin, religion etc. There are a few questions that Polanyi asks and that I will try to answer, limiting myself to my research field. It is important to note that scientific research today is very much diversified. It is quite possible that different scientific/technical fields require different questions and answers. Think, for example, how diverse basic research in astronomy and biology and medicine are. Astronomy and cosmology have as their objective the studying of systems that are several orders of magnitude bigger than – and therefore ‘distant’ from – human beings. The universe as a whole – in its origins and evolution – is subject to careful investigations using mathematical and physical tools. Compared to astrophysics, biology and medicine are certainly capable of attracting all sorts of different questions that can ‘touch’ us more directly. This is because the investigation comes closer and closer to human beings. Investigations in astrophysics, on the other hand, tend to go away in time and space from us. It is therefore quite ironical but perhaps not unexpected that there are scientists today advocating the ‘anthropic principle’ according to which the Universe is compatible with the conscious life (us) observing it. In other words, the Universe has the exact age and values of the physical constants to allow the arrival of the human race. Therefore it should not be a surprise that we are here now.

Let us go back to the organization of science: I will limit myself to questions in the field of astronomy. The first question is: ‘how are scientists chosen?’ The second is: ‘How are scientific problems chosen?’ I will deal with the first question here, and with the second question in the next section.

The approach to physics and astronomy differs over time with a different degree of increasing complexity, from the simple everyday physics understood by small children, to some general simple physics for pupils in school, to the more rigorous basic physics of University graduates. Each of these groups comes closer to a more modern understanding of the natural world. If you want to become an active researcher you need to step up one more level. To become a scientist you need to be in touch with the people who are active in research. Your first step is to look for a PhD thesis: you are now looking to become part of an inner circle of scientists with an international reputation. It is like an 'initiation' with its own rites. In astrophysics, you need to choose (or be chosen by) a good PhD supervisor. Your future is now in his/her hands. After having worked very hard on your thesis you must publish your results and give presentations at international workshops. However be careful not to go too far against the flow and, more importantly, do not go against the current 'fashion' theories and/or experiments. These fashion theories/experiments are normally supported by those few powerful big names with a lot of influence in directing the scarce funds available in your research field. After your successful PhD defence, you need to look for a job, first a fixed-term contract as Post Doctoral Research Assistant (PDRA), and then as a lecturer or assistant professor. You succeed and become a PDRA. Your destiny is in the hands of the academic in charge of the funds from which your salary is paid. You work very hard and, only if you are very good and lucky, you are now allowed by the academic staff of a certain University to become a young lecturer. You are chosen to become an academic staff member because you are good at your research. At this point, you discover that you do not have enough time to do the research that you are good at: you now have to teach, supervise students and participate in the administration of the department. Therefore, to keep your scientific production you apply for funds to employ PhD students and PDRAs to help you with your research and so on...

The process that I just described is obviously simplified and certainly not comprehensive but it probably gives an idea of the process of selection of scientists. It is by acceptance by your peers into an inner circle of initiated scientists. It is thus an oligarchic process, the one through which scientists can do their job. The arena where this initiation takes place consists of international journal papers, workshops and internet publication of pre-prints. The real power resides in a group of established scientists that are called to be part of the process of distribution of government resources in the form of panels or reviewers of proposals. Above them, there is certainly the politics that establish how much money will be available in each discipline – if any. Once your scientific result is passed through the opinion of the big names in your field, then the validation of theoretical studies or experimental data is a real democratic process. The entire community expresses their views on the material published. The value of the results emerges naturally although, in some cases, if

they are too revolutionary, it will take some time to pass a very close scrutiny by the scientific community. In this sense, scientists are very conservative and I would like to add, rightly so! There are cases of exaggeration of conservatism when the new results are in clear conflict with the scientific reputation of some big names. If the name is particularly big, sometime it is necessary to wait for his/her retirement. Max Planck, the famous German scientist and father of quantum mechanics has expressed this concept in a very caustic but effective way: 'A 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.'² In other words, science progresses from death to death.

Relationship between science and technology

The question I posed above is: 'How are scientific problems chosen?' There is apparently a complete freedom in choosing the problems to be studied. In reality, however, scientists need funding to carry on their studies and therefore a first screening is always applied by your peers. Therefore, scientific problems are chosen with a similarly oligarchic process to the one through which scientists are selected. Both scientists and ideas are selected by peers, or, more properly, by the experts in the field. In this sense, this oligarchy 'justifies' the research. However, as I will discuss below, this does not fully resolve the moral maze I highlighted above. The very original ideas that have revolutionized the world quite often do not pass through this scrutiny: they might not survive it! Instead, scientists often piggy-back novel research on other funded research or – in a few cases – even with no funds. I am not sure if this is good or bad, but it is certainly the way it is today. I must mention that, in accordance with this model of regulation of funding, the number of scientific revolutions has decreased in the last few decades. Are we scientists becoming more traditional than our colleagues of fifty-plus years ago? Perhaps yes, in spite of the fact that the number of professional scientists has hugely increased in the last thirty years. I am not surprised because the amount of knowledge has also increased enormously. The more knowledge we accumulate the larger the boundaries to the unknown are and the more people are needed to keep pushing the ever-enlarging boundaries to the unknown. Basic research is the science located close to these boundaries and pushing out. The inner science is more technological and directed at translating the scientific results into applications useful to human beings.

It is important to reflect on the relationship between science and technology, to begin to unravel the ethical issues around freedom of scientific research. Although basic science may appear not directly to affect human welfare, in fact

many of the problems affecting society can be solved by operating on a twofold front: basic research and technological research. This may begin to explain the ethical importance of basic research.

Basic research will open completely new directions to solve problems that more established research is struggling with. Current established technology is improving our standard of living on time scales that are more evident to our current generation. Basic research is more for the distant future while technology research is for today or the near future. It is evident therefore that economic interests will tend to favour technology research because of the potential near term financial returns. My point is that both research activities are needed to maintain our desire to improve our life and the life of the future generations.

The importance of basic research

Basic research is curiosity driven, blue-sky research that sometimes might lead to big discoveries but most of the time the outputs remain relegated to some technical journal unknown to the general public. Scientists involved in basic research should therefore sometimes feel the moral obligation to justify the resources used. My view is that this research is always justified by the potential huge advantage that can result in the future. Almost all the big discoveries resulted from blue-sky research and there is no indication that this is not going to be the case for future discoveries. Let me mention just a few: maser/laser, Mendeleev periodic table, transistor, optical microscope, X-ray diffraction which led to medical screening and discovery of the DNA structure, steam engine, electricity and magnetism. These are only a few examples. Scientists should continue putting their best efforts into basic research being aware that their work is not only a service to human knowledge, but potentially can help solve bigger problems such as, for example, the energy sources of the future. It is absolutely vital that we understand the value of the basic research that apparently will be relegated to technical journals with no immediate social application. People designing the first nuclear reactor, for example, made heavy usage of techniques discovered by basic scientists like Enrico Fermi. Fermi's scientific output was exclusively based on blue-sky research and relegated to technical journals. Even more representative is the understanding by astrophysicists of the process of nuclear fusion in stars. This discovery generated the thermonuclear bomb, which is massively more powerful than nuclear bombs, but also the potential of fusion reactors, which some hope will solve the energy problem of the future. It is important to realize that the current generation of researcher is building upon a huge amount of knowledge generated by the blue-sky research performed by scientists of the previous generations. Newton himself expressed this point very effectively when he said

to Robert Hooke in a famous letter dated February 5, 1676: *'If I have seen a little further it is by standing on the shoulders of Giants.'*

In the past it was relatively easy to identify the big thinkers who started important scientific and technical revolutions – the Giants. Today, the Giants are composed of a collection of scientists standing on top of each other. The scientists on the top would not be able to see far without all the scientists whose work allowed them to make the important discoveries. It is a much more democratic view that shows the scientific progress as a synergetic endeavour of many scientists often working in different fields.

Basic research in astrophysics is about trying to answer the big questions about our cosmic origin. This research effort has apparently no connections with everyday life. In reality, increasing the knowledge in any field will generate more curiosity that, in turn, will trigger new discoveries in different fields. It is very important to always keep in mind that scientists are managing taxpayers' money. The ultimate judges are the people that contributed their hard earned money to allow us to do blue-sky research. We must therefore have rules of conduct to make sure that their money is well spent. Honesty in reporting experimental results or in reporting the output of very complex calculations or simulations is perhaps the most important rule of conduct. We scientists are trained to question very hard any result being discussed. There is always space for doubts in our minds even when we are reasonably sure that a certain result holds. After all, we will never prove that a theory is correct: we can only prove that is wrong!

Moral responsibility

After having explained how scientists and ideas are chosen, and having stressed the benefits of basic science, I will now turn to my original question: is it morally acceptable to spend money on basic blue-sky research instead of saving lives immediately by building more hospitals? Our generation is investing resources to improve the life of future generations. It is a natural force at work: we invest for our children. We want future generations not to go through what we went through. It is probably true that if we spent all the money destined to science into building hospitals or buying food we would save a lot of people from health perils and premature death. But it is also true that the scientific advances made in the past have saved a lot more people who would not have been saved if we had not invested. A very crude representation of this concept would be that the people dying today because of lack of resources are giving their life to make the future generations healthier and more comfortable. These people are the real modern heroes – and martyrs. I am not saying that this is right or wrong; it is not up to me to judge it and, in any case, it would be completely beyond my control as a scientist.

I have been trained as a scientist and not as a philosopher or as a sociologist and therefore my thinking might sound naive. However, I cannot resist mentioning that if we want to be effective for our current and future generations perhaps it would make more sense investing less in armaments and more in science rather than less in science and more in direct technological applications. Some scientific advances made via basic research can be effective even during the lifetime of a human being. Without antibiotics, discovered by Fleming in 1928, many of the people around us today would be dead – perhaps many of us or our own fathers or mothers. We understand better our world and contribute to a human endeavour that does not have limitations in terms of languages, skin colour or geographical location. Science is really a global effort at a world level with no limitation in space and time. Therefore, the life improvement and life saving that may result from basic science favours humanity as a whole, as compared to investments in technological applications, which may favour only selected parts of humankind. And this is another reason why it cannot be unethical in principle to invest in basic research, even if no direct application can be precisely predicted.

I would like to finally spend a few words on the moral responsibility of researchers when technology is used for applications leading to the construction of weapons or similar unethical activities. I think that there is no bad science or good science. There is just science. Scientists working in Universities and research labs are curiosity driven individuals. They have no responsibilities for the usage of the results of their research. Scientists discovering nuclear fission in all likelihood were not thinking about the bomb. The scientists that worked on the Manhattan project – the program that developed the first atomic bomb – on the other hand, knew what they were doing. They were using/developing the known basic research during wartime to create a weapon. I am pretty certain that if it were not wartime, then these scientists would never have worked to create such a horrible device, but in time of war every man and woman is confronted with very difficult moral questions: better to kill 1 today to save 100 tomorrow? This dilemma is a dramatic version of the dilemma posed previously about building hospitals versus funding basic research. They look to me as logically equivalent. This is not necessarily to suggest that investment in development of weapons is morally justified. This is instead to point out that the big decisions about budget spending of a nation have as a consequence that some people will die and some others will not. In a democracy, politicians are elected to represent people and therefore the responsibility of these ethical decisions belong to the voters and not the individual scientists or engineers.

A scientist like me when confronted with non-scientific problems, like for example social problems, is generally lost. I am not trained to approach systematically these classes of problems because I suspect that they are too difficult when compared with scientific problems. Corbellini, in his chapter in this volume, has delved into the relationship between democracy and science

development in far greater depth than I could hope to. He stresses how freedom of science is needed in order for democracy to flourish, but clearly public consultation, and transparent methods of allocation, as Corbellini points out, is also a way in which we, scientists, can operate with some sort of legitimacy.

I would like to conclude with some wisdom coming from the accumulation of thousands of years of experience. I find the following Buddhist proverb very enlightening: *'To every man is given the key to the gates of heaven; the same key opens the gates of hell.'* Scientists study the mechanism of the key. Politicians use it.