Arno A. Penzias: Astrophysicist, Nobel Laureate

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From their observations made in 1964 and 1965, Dr. Arno A. Penzias and Dr. Robert Wilson of Bell Telephone Laboratories first discovered the now estimated 3 K background microwave radiation in the universe - one of the first and still one of the major lines of evidence in support of Big Bang cosmology. In the minds of many in the scientific community, this discovery supports the view that the universe created itself. Browne (1978) interviewed several of the world's leading physicists, astronomers and cosmologists. "A majority clearly shared the somewhat gloomy view of Dr. Steven Weinberg, a well-known [former] Harvard University particle physicist whose book about the origin of the universe, *The First Three Minutes*, appeared recently." In Weinberg's words, "The more the universe seems comprehensible, the more it also seems pointless.... The effort to understand the universe is one of the very few things that lifts human life a little above the level of farce, and gives it some of the grace of tragedy" (Weinberg, 1977).

Browne discovered in his research that some scientists shared "a contrasting view" to that of Weinberg. One of these scientists was Dr. Penzias himself, who, "despite the part his observations played in expanding the thinking of such physicists" as Dr. Weinberg, "believes that they are wrong in asserting that the universe is pointless" (Browne, 1978). The crux of the matter, as Penzias sees it, is that the empirical evidence actually argues for a created universe.

> If the Universe hadn't always existed, science would be confronted by the need for an explanation of its existence. Since scientists prefer to operate in the belief that the universe must be meaningless - i.e., reality consists of nothing more than the sum of the world's tangible constituents - they cannot confront the idea of creation easily, or take it lightly. Well, I hope that we, as modern people, might be able to leave dogma aside and be willing to look at facts, at least the facts as we understand them today (Penzias, 1983, pp. 3-4).

Specifically, Penzias' research into cosmology has caused him to see "evidence of a plan of divine creation." He says that "the best data we have are exactly what I would have predicted, had I had nothing to go on but the five books of Moses, the Psalms, the Bible as a whole" (Browne, 1978). Penzias asks:

How could the everyday person take sides in this dispute? ... trying to fit dogma and fact into the same mind seems too difficult....wanting to hold on to the teaching of faith, but as a rational person wanting to keep a grasp on everyday facts - [one is] being pulled by two opposing "truths." One held that the universe was created out of nothing, while the other proclaimed the evident eternity of matter. The "dogma" of creation was thwarted by the "fact" of the eternal nature of matter .... This dogma comes from the intuitive belief of people (including the majority of physicists) who don't want to accept the observational evidence that the universe was created - despite the fact that the creation of the universe is supported by all the observable data astronomy has produced so far. As a result, the people who reject the data can arguably be described as having a "religious" belief .... These people regard themselves as objective scientists. The term "Big Bang" was coined in a pejorative spirit by one of these scientific opponents who hoped to replace the evolutionary universe idea with a steady state theory - one which said that the universe has always looked exactly as it looks now. More recently, this now-discredited attempt has been replaced by an oscillating universe theory, one in which the cosmos explodes and collapses throughout eternity. (Penzias, 1983, p. 3)

Unfortunately, Penzias has not published much on his theological views, but in his few interviews and papers on this topic, he has made his general views clear, as the following comment reveals.

I invite you to examine the snapshot provided by half a century's worth of astrophysical data and see what the pieces of the universe actually look like .... In order to achieve consistency with our observations we must ... assume not only creation of matter and energy out of nothing, but creation of space and time as well. Moreover, this creation must be very delicately balanced. The amount of energy given to the emerging matter must be enough to move it fast enough to escape the bonds of gravity, but not so fast that the particles lose all contact with each other. Enough of the initially-created matter must pull together under gravity to form galaxies, stars, and planetary systems which allow for life. Thus, the second "improbable" property of the early universe, almost as improbable as creation out of nothing, is an exquisitely delicate balance between matter and energy. Third - and this one puzzles scientists at least as much as the first two - somehow all these pieces, each without having any proper contact with the others, without having any way of communication, all must have appeared with the same balance between matter and energy at the same instant. (Penzias, 1992, p. 80, 82)

Penzias also argues that theology can tell us much about what we would expect the universe to be like. For example, he concludes that if it is open, expanding forever, the universe would be "precisely the universe that organized religion predicts." Specifically, he notes that

a theologian friend of mine ... told me once he could not conceive of Calvary happening twice. He said his faith as a Christian would be shaken if it could be proven to him that the universe, with its finite number of particles, could be reconstructed an infinite number of times. It would mean that every event - the creation of man ... everything - would be repeated again and again an infinite number of times, simply by random chance. That is the meaning of infinity. In other words, a closed universe would be [as] pointless as the throw of dice. But it seems to me that the data we have in hand right now clearly show that there is not nearly enough matter in the universe, not enough by a factor of three, for the universe to be able to fall back on itself ever again. (Browne, 1978)

Penzias recognizes that these views are uncommon in science. In his words, "very few winners of Nobel Prizes in science, and for that matter very few scientists generally, have been strong religious believers" (Browne, 1979). Penzias believes drawing conclusions in the faith-science area is compounded by the fact that:

As our sophistication increases, we habitually categorize the sum of experience, using names like "theology" and "astrophysics." But categorization leads to separation. In particular, our understanding of the world around us has grown along two parallel courses, based on largely separate portions of the entirety of human experience. (Penzias, 1992, p. 78)

He not only questions the wisdom of separating reality into artificial divisions such as science and theology, but concludes that doing so may impede a complete understanding of the universe:

...In ancient times, theology outweighed the barely-formed precursors of physical science. But physical knowledge soon began to grow in prestige as well as size. By the end of the middle ages, theology could no longer ignore science. The resulting dichotomy between tangible and intangible knowledge perplexed many of our own great scholars - none greater than Rambam himself ... [said:] "The foundation of our faith is the belief that God created the Universe from nothing; that time did not exist previously, but was created; for it depends on the motion of the sphere, and the sphere has been created" (1946). Maimonides' "dogmatic" position that the universe was created out of nothing conflicted with [contemporary] "empirical" data - data from none other than Aristotle himself - that matter was eternal. (Penzias, 1983, p. 1-2)

Although recognizing that some questions are outside of science, he nonetheless values asking questions in all areas, concluding that the ability to ask "good questions" rather than just the ability to learn, is the factor that "best distinguishes organisms that possess intelligence from those that do not" (Aleksander, 1989, p. 310). Good questions can also help to distinguish truth from lies:

In [Panzias'] 1989 book ... he compares the rigidly defined terrain of computer logic with the improvisational thinking of Sir Arthur Conan Doyles' Sherlock Holmes. Holmes, in Penzias' view, uses his intelligence to distinguish between the truth and lies presented as fact. This is what separates man from machine, Penzias notes, for no machinery exists today with the human ability for judgment or opinion. (Fleming, 1990, p. 28)

The Man Behind These Words

Penzias is not only a Nobel laureate, but has earned numerous other awards, such as honorary doctorates by Rutgers University (*New York Times,* 1975) and many other institutions. He was born in Munich, Germany in 1933. When he was four years old, his parents fled Nazi Germany, eventually arriving in Brooklyn, New York (Webber, 1980). His father was a Polish citizen and his mother was German. Once in America, Penzias attended Brooklyn Technical High School and City College of New York from which he graduated in 1954 (his alma mater later honored him with an honorary doctorate - *New York Times*, 1979). Penzias served in the U.S. Army Signal Corp., then pursued graduate studies in physics at Columbia University (Moritz, 1985).

His thesis was under Nobel Laureate Charles Townes and focused on the measurement of free hydrogen radio emissions from the Pegasus I cluster of galaxies (Webber, 1980). Penzias began his lengthy career at Bell Telephone Laboratories in 1961, where he has continued his research, taking advantage of the excellent radio astronomy facilities there (Lubkin, 1978). As Vice President in Charge of Research since December of 1981, he is still very involved in science advancements (Bernstein, 1984, p. 215). As of 1990, Bell Labs employed 22,900 workers, and had a budget of 2.9 billion dollars (Crease, 1991). Penzias explains how he became involved in the field of physics in the following words.

After about one semester ... [at the City College of New York] I was sick of chemistry. I had taken so much in high school .... It involved a lot of memorization of stuff that I already knew. I also took elementary physics, which was taught by a very nice teacher named Hardy. I went to see Professor Hardy and I asked him, "Can a physicist make a living?" ... He said that physicists think they can do anything that an engineer can do, and if they can do that they can at least make a living as engineers. I said, "Fine" and switched majors to physics. (Bernstein, 1984, p. 220)

Working with him at the Columbia Physics Department were Nobel Laureates I. I. Rabi, Polykarp Kusch, Tsung Dao Lee, and Charles Townes. Penzias says that he struggled to get through Columbia and sometimes managed only by receiving incompletes and taking the exams later. The problem was not Penzias' abilities - he was extremely bright and capable - but because the Columbia physics department was highly demanding. He recalls he was once given five questions on a test in an optics course, of which he was sure about none of the answers. When he looked around the room, it appeared that the rest of the students could do the exam, so he plunged in. Penzias ended up with a score of 54 - the second highest mark in the entire class. For his Ph.D. thesis with Professor Townes he built the world's second radiation detection radio telescope. This unit was designed to pick up the specific radio wavelength emitted by hydrogen atoms, namely 21 centimeters. Penzias also worked on developing a large radio antenna to help detect hydrogen in space - the gas then thought to be present in the space between the galaxies - in order to complete an intergalactic hydrogen catalog. He found that many critical published calculations were incorrect, and had to modify his equipment, but still finished the study with "disappointing results" (Moritz, 1985, p. 329). Nonetheless, the young student learned a great deal and earned his degree.

When Penzias joined Bell Laboratories, he was put on the antenna pointing committee to solve measurement errors that occurred because the steel antenna bends under gravity, wind load, and temperature changes. Nor were the antenna's gears perfect, and its foundation was not perfectly horizontal either. A committee was formed to solve the precision problem, and Penzias' solution was to place a second receiver in the antenna which could be pointed at a known natural source of radiation, such as the remnants of an exploded star (Bernstein, 1984, p. 225). Then, by comparing the radio telescope's data to the star's known position, the operator could tell how far off of calibration the instrument was. After Penzias marked success in this area, he began working with the horn antenna at Crawford Hill doing radioastronomy.

One reason Bell Telephone Company funded basic research was because it allowed the company to exchange information with other scientists, who would then reciprocate with information that Bell needed which was developed at other science labs. Penzias was researching the hydroxyl molecule (-OH) in outer space when Robert Wilson joined the Bell Laboratory team in 1963. Bell had at this time moved out of the satellite communication area, and so the horn antenna that was built to communicate with the ECHO and TELSTAR satellites became available for full time radioastronomy. The two scientists then proceeded to make numerous discoveries. For example, in 1970, along with Keith B. Jefferts, they discovered carbon monoxide in the Orion Nebula. Soon after this feat they discovered ethyl alcohol, hydrocyanic acid and scores of other molecules in space. In Penzias' words: "The millimeter portion of the spectrum is so rich that it is hard to take an antenna and point it at certain sources in the sky and not find new lines" (Bernstein, 1984, p. 227).

It was in 1978 that Penzias and Wilson were awarded the Nobel Prize in physics for their discovery of the 3K background radiation because of its perceived significance for Big Bang cosmological model (Hudson, 1978). Prior to this, Bell Lab's radio telescope unit, which was originally designed for satellite communication, was modified to help Wilson and Penzias measure the intensity of radio waves emitted by the gas halo which surrounds our galaxy. A major advantage of this unit was that it was more directionally sensitive than other units of the day. The two scientists were researching the intensity of radio waves emitted from this halo of gas at the Holmdel, New Jersey radio telescope when they made their best known discovery (Lubkin, 1978).

The discovery which, according to Gwynne (1978) "changed the face of modern cosmology" occurred while Penzias and Wilson were doing their routine communication research. They picked up a disconcerting background noise which persisted even after replacing the components which they felt could be producing the mysterious hiss. Since the background static interfered with their communications research, they were concerned to try to determine the cause, so as to eliminate it. Attempted solutions included cleaning pigeon droppings from their twenty-foot horn reflector antenna, as well as removing a pair of pigeons. However, the problem still persisted. They finally stumbled upon the idea that the noise was not interference, but that they were picking up a cosmic background noise. This is now generally interpreted to be what is left of the detectable echo of the Big Bang, which still permeates space.

Originally believed to be in the visible light area of the electromagnetic spectrum, the radiation has decayed to the microwave frequency and is now estimated at 2.73 K. When Penzias and Wilson discovered that the radio waves in the microwave frequency band were in fact emitted in every direction that they could measure, they began the research to find out why (Donovan, 1978). Researchers at Princeton, primarily Professors Robert H. Dicke and P.J.E. Peebles, first led them to the idea that this static may in fact be the first direct evidence of the Big Bang model. This model predicted that the universe emitted black body radiation at a temperature of about 5.0 above absolute zero, about twice that actually found (Webber, 1980). Penzias' thoughts on the Big Bang cosmology that his research was so important in establishing are reflected in these words:

> ...proposed modifications to the Big Bang theory such as the "bubble theory" ... have to do with hypotheses for how this universal perfection could have happened without violating our understanding of the laws of physics. The bubble theory is a mathematical attempt at getting around our third "improbable" observational fact. As of now, the attempt seems to have been unsuccessful, but the importance of the challenge suggests that scientists will continue to pursue such lines of attack.
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> Before concluding, I can't resist bringing up the "Missing Mass:" the difference between the amount of matter astronomers find in the Universe and the much larger amount needed to reverse the flight of the galaxies (and ultimately pull them back into a single condensed state). Naively, one might imagine hunting for matter as a kind of astronomical inventory, one in which the total climbs as overlooked nooks and crannies are examined ... [A]s astronomers "weigh" the sun by measuring the motion of the earth, we infer the mass of the universe from the motion of the galaxies themselves. Those motions point to a universe

which will fly apart indefinitely - not one which will someday collapse to a point. Thus, observations also contradict the notion that our Big Bang is just one of an infinite series of such events. (Penzias, 1983, pp. 7-8)

Much is still not known about cosmology, and this is reflected in the many debates about the widely accepted, but still hotly disputed Big Bang model of cosmology (Odenwald and Fienberg, 1993; Lerner, 1991). And just what does all this lead up to? Penzias says:

In summary, therefore, astronomy leads us to a unique event, a universe which was created out of nothing, one with the very delicate balance needed to provide exactly the conditions required to permit life, and one which has an underlying (one might say "supernatural"), plan. Thus, the observations of modern science seem to lead to the same conclusions as centuries-old [creation beliefs].... At the same time, most of our modern scientific intuition seems to be more comfortable with the world as described by the science of yesterday. (Penzias, 1983, p. 7-8)

Although most famous for the discovery that is now most often used to support broad Big Bang cosmology, Penzias' greatest achievements are in other areas, primarily information technology. This is not unexpected, in view of the primacy of the "information argument" in the designed universe world view that he holds (Johnson, 1991). As head of the largest and most productive information technology research lab in the world - they publish around 3,000 papers a year - he has been a leader in the information revolution that has changed our world (Fleming, 1990; Penzias, 1989a; 1989b; Gilder, 1989). He also is active in his own research and continues to make contributions to radio-astronomy and related areas. That his discovery is not unequivocal evidence for the Big Bang, and can be interpreted in other ways, does not detract from his achievements. One alternative explanation is that the background radiation arises "from dust grains that have been heated by starlight" (Goldsmith, 1985). A major cause of microwave background radiation may also be from extremely distant quasars (Narlikar, 1981, 1991).

NOTES

Scienctists have gathered an enormous amount of empirical data in their quest for an understanding cosmology and the universe as a whole. Science, by its very nature and through replication, is able to produce empirical data that is widely accepted as valid, but, unfortunately, the interpretations of this data often vary. Because this scientific data is frequently used by many individuals in order to support their atheistic world views, the views of eminent scientists such as Arnold Penzias are useful in helping others to evaluate common interpretations of data. This review of one aspect of Penzias' work, although he has written only briefly about this subject, provides much insight into other possible conclusions in the admittedly rapidly evolving, and currently highly debated, field of cosmology. It is also apparent that it is not uncommon for pronouncements about cosmology and origins made in the mass media, and even by scientists, to be premature, and at times irresponsible. The importance of one's world view often is of major importance in interpreting the data, and understanding this concern is paramount in evaluating the conclusions of researchers.

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