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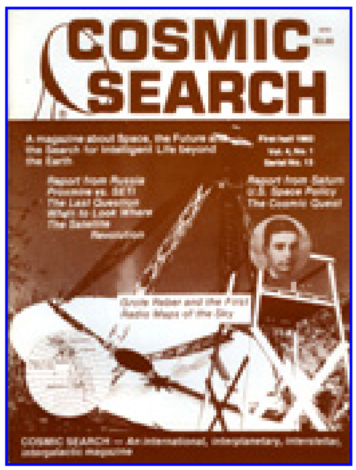

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[Article in magazine started on page 30]

SEnTInel

By: Robert S. Dixon

Proxmire vs. SETI

Readers of **COSMIC SEARCH** may recall that Senator Proxmire of Wisconsin gave his infamous "Golden Fleece" award to the NASA SETI program several years ago, and succeeded in setting the appropriation for that item in the NASA budget to zero. This effectively scuttled any major SETI effort by NASA for the time being, but did not seriously affect the very small-scale "back-burner" internal studies that had been going on for some years within NASA. There are many similar small NASA programs, involving only a few people each, with tiny budgets which delve into a wide variety of space-related scientific topics.

Now Senator Proxmire has attacked even this tiny internal study program, with the net result that no NASA funds appropriated for the period October 1, 1981 through September 30, 1982 can be spent on SETI. What seems to have attracted Senator Proxmire's ire is a magazine article which said that NASA was hoodwinking Congress by secretly continuing SETI despite being told not to do so. In fact this is not true, because Congress had earlier authorized NASA to proceed with SETI, but Proximire set that budget item to zero, leaving them with permission but no funds. NASA normally always has internal discretionary funds to carry out small pilot studies in any area they choose that is related to their mission.

This may be the first time that a congressman has gone to the extreme of attacking one of these tiny internal NASA programs, and it has attracted the anger of other congressmen and many NASA officials. Their feeling is that Proxmire is carrying out a personal vendetta against SETI, perhaps to attract publicity to himself, when he should be concerned about other more important things. Senator Proxmire's action appears to have generated a backlash of wide support for SETI, which may in the long run prove advantageous. The mood is "just wait until *next* year!"

The net result of Senator Proxmire's latest attack will be a few (at least temporary) lay-offs of NASA workers, and curtailment of small grants to several universities which are carrying out research in this area. Senator Proxmire has a reputation in scientific circles for not really understanding the projects that he criticizes. This appears to be the case this time as well. He was quoted by the Associated Press as saying that "intelligent life might be extinct by the time Earth received and replied to a message." Presumably he was referring to *extra*terrestrial intelligent life, although one could argue both ways. The fact is that no one is proposing to reply to any message at all. There is no need to. We would reap most of the benefits by just *receiving* a single signal, thereby proving that man is not alone and unique in the Universe. Then if we could go one step further and *understand* the message contents of the signal, we would again reap most of the remaining benefits.

The appropriate analogy is listening to your radio, watching television or reading a book. You have no intention of "answering back," yet you find the activity worthwhile and educational. SETI is searching for broadcasts, not for conversations. The time to reply may not come for centuries after we receive a signal. There is no hurry. We would want to plan our reply very carefully.

We will be monitoring developments in this area, and will keep our readers informed.

The Seasons of Star Birth

Conventional galactic formation theory says that different sizes of stars have been born at about the same rates since the beginning of the galaxy. This belief has now been questioned by R. Caimmi of the University of Padova, Italy, in *Astrophysics and Space Science*, volume 79, p. 87 (1981). Caimmi has investigated the metal content of stars and finds too few low-metal stars and too many high-metal stars, relative to what uniform star formation rate theory would predict.

The metal content of stars increases with each succeeding generation because metals are created only in the cores of stars, and when the stars die, they often blow themselves up into interstellar gas, which is then used to create the next generation of stars. Big stars are better at metal production than little ones, because they are more likely to blow up at the end and because their lifetimes are shorter. Thus, if the big and small stars are not born in the same relative abundances at all times, the rate of metal production in the galaxy will be affected.

Caimmi concludes that the present distribution of metal in stars could not be the result of uniform star formation in all sizes. There must have been "seasons" in the past when only big stars (at least ten times the size of the sun) were born, and no little ones (like the sun) at all. There may have been about three of these seasons in the history of our galaxy. During these times, metal production occurred at a relatively feverish pace, since all the interstellar gas was being used up to form short-lived big stars, and none was being locked up in long-lived little stars.

These seasonal effects could be important to understanding the evolution of life as well, since supernovae would be frequent during the big-star seasons, and might tend to adversely affect life that had begun during the preceeding little-star season (life is generally associated with little, rather than big, stars). And of course anything that indirectly affects the formation and evolution of little stars has a direct bearing on our estimates of life in the galaxy, both present and past.

A Neutrino Telescope Becomes Possible

Neutrinos are subatomic particles that have no mass (or at most very little) and no charge. Because of this, they are very difficult to detect even though they are very numerous in the universe. They are created as by-products of various nuclear reactions, such as those that occur continuously in the Sun. Much could be learned about the origin and structure of the universe if we had a neutrino telescope capable of detecting them with reasonable sensitivity and able to indicate the direction from which they are coming. Since neutrinos do not interact appreciably with matter, they easily penetrate even large objects like the Earth. This makes them potentially useful for long-range communications.

Such a telescope has just now become possible for two reasons. First, someone just thought of a way to make it work, and second, our technology has only in the last two years reached the necessary level of sophistication to actually build one.

Martin Harwit, of Cornell University, published his idea in the *Monthly Notices of the Royal Astronomical Society*, volume 195, p. 481 (1981). He points out that neutrinos are known to spin about an axis that is parallel to their direction of motion. In addition an isotope of Indium is known that will be converted to an isotope of Tin if a neutrino strikes it in the correct way. The neutrino must strike the Indium nucleus along the axis about which the Indium nucleus is rotating. Not only that, their spins must be in the opposite direction (i.e., the "north pole" of the neutrino must hit the "north pole" of the Indium nucleus), When this happens, the neutrino is absorbed into the nucleus, and the spin of the nucleus is slowed down by its having to absorb the angular momentum of the oppositely rotating neutrino. Since energy must be conserved in this reaction, an electron is then expelled from the nucleus to carry away the original energy carried in by the neutrino. It is this lost electron that changes the nucleus from Indium to Tin, but the important thing is that the electron can then be easily detected, and its presence indicates the fact that a neutrino was orginally present. (Similar kinds of indirect detection, where the presence of one particle is used to indicated the presence of another, are quite common in nuclear physics.)

If the spins of the neutrino and the Indium nucleus are not exactly opposite, absorbtion does not always occur. If they are aligned in the same sense, i.e., "north pole" hitting "south pole," then absorbtion never occurs. This provides a directional effect since the Indium nucleus could be steered around to "point" in different directions. This directional pattern is proportional to $1+\cos\theta$ where θ is the angle of misalignment from the optimum case.

The technological problem is how to make a sufficiently large quantity of Indium have all its nuclei aligned in the same direction. This requires cooling the Indium to .003K (to stop the random tumbling of the nuclei) and subjecting it to a very powerful magnetic field. A superconducting magnet is required, and the strongest available magnets are just able to do the job. Several tons of Indium would be required (already somewhat difficult, since Indium is not a common metal), and magnets and refrigerators large enough to hold that much have not yet been constructed. Nevertheless, the technology is available, and it is more a matter of engineering and cost than of technique.

Harwit believes that a neutrino telescope could be constructed that is capable of not only detecting neutrinos from the sun, but of pinpointing the portions of the sun from whence they came.

An earlier **COSMIC SEARCH** article by Pasachoff and Kutner on "Neutrinos for Interstellar Communication" appeared in the Summer 1979 issue.

Pregalactic Stars vs. The Big Bang

For many years scientists have been studying the 3-degree background radiation that seems to bathe the entire universe. The fact that this temperature is the same as what is believed to be left over from the primordial big bang lends great support to the idea that they are one and the same phenomenon. However, as more accurate measurements of the 3-degree radiation continue to be made, some discrepancies are being found. The shape of the curve that describes the strength of the radiation at various frequencies (i.e., its spectrum) no longer fits the predicted black body curve very well. This has led to the idea that perhaps part of the radiation is caused by something else, and the most likely candidate is ancient stars — stars that existed even before any of the galaxies were formed.

Now B.J. Carr, of the Institute of Astronomy in Cambridge, England is suggesting that *all* of the background radiation may be due to these pregalactic stars. He writes in the *Monthly Notices of the Royal Astronomical Society*, volume 195, p. 669 (1981) that large pregalactic stars and their black hole remnants could have heated up the interstellar dust sufficiently to cause the observed background radiation. If Carr's theory turns out to be correct, it will require significant changes in our ideas about the origin of the universe and the formation of the galaxies.

Gravity Lenses Won't Focus Gravity Waves

Gravitational lenses are now believed to cause multiple and distorted images of very distant objects. This occurs when a foreground galaxy is between us and a more distant object, so that the gravitational field of the galaxy "focuses" the light and radio radiation from the background object in various complicated ways. Some applications of this effect were discussed in Sentinel for Summer 1980.

Both radio and light are electromagnetic and the effect of gravitational lenses on electromagnetic waves seems to be well understood. However, what is the effect of gravitational lenses on gravitational waves? This is of importance because our current gravity wave telescopes are rather feeble, and if we could make use of some object (like the sun) as an amplifying lens it would be a boon to gravity wave astronomy. This question has been addressed by a number of workers, and most recently by Robert Bonz and Mark Haugan of the University of Utah, as published in *Astrophysics and Space Science*, volume 78, p. 199 (1981).

Their mathematical analysis reveals that although geometrical optics theory predicts very high amplification of gravity waves at certain places called caustics, in practice the amplification is limited by diffraction effects to lower values, and in fact is limited to zero below some cut-off frequency. This means that only high-frequency gravity waves can be amplified by gravitational lenses. The cut-off frequency is inversely proportional to the mass of the lens, and is independent of everything else (such as the shape of the lens). In other words, big objects can amplify lower frequencies than little objects.

Taking a specific example, the cut-off frequency for the sun is about 2 kHz. Unfortunately, natural gravity waves have frequencies ranging from about .0002 to 2 kHz, being most typically about 20 Hz. Thus, the sun is just too small to be of any practical help in receiving natural gravity waves. On the other hand, if a civilization was transmitting gravity waves at high frequencies (chosen to avoid the "noisy" lower frequencies), the sun would work nicely as a means to help receive them.

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