Publications Watch

By Andrew J. LePage

Notes on recent books and articles pertaining to SETI and bioastronomy.

Astronomy

July 1996, Volume 24, Number 7

"OK, Where Are They?" by Robert Naeye, pp. 36-43

An associate editor of *Astronomy,* Naeye reviews recent thinking on the likelihood of finding extraterrestrial intelligence (ETI). Unlike the rosy picture typically painted in the popular astronomical press, the author defends the position that the occurrence of ETI is exceedingly rare and that we may be alone. To support his position, the author makes use of many recent studies on topics ranging from the prevalence of Jupiter-sized planets to the steadying effects of large moons on the evolution of their primary's axial tilt.

This reviewer differs with Naeye on the interpretation of certain facts and the relative importance of some of the arguments presented. However the uncertainties involved in many issues surrounding the emergence of ETI just as easily support this pessimistic position as the more optimistic, pro-SETI position commonly found in the press. This article is definitely worth a read and includes its author's e-mail address at the end for reader feedback.

"Starmaker, The New Story of Stellar Birth," by Adam Frank, pp. 52-57

This article gives a good summary of the current theories of star formation. Frank, an astrophysicist with the University of Minnesota, presents a piece primarily concerned with the origin of spectacular features such as polar jets. But there is also much discussion on the disks of dust and gas that adorn newly forming stars and the details of the transfer of angular momentum in these systems. These topics are also important issues in the planet formation process.

Astronomy & Astrophysics

February (I) 1996, Volume 306

"The First Images from an Optical Aperture Synthesis Array: Mapping of Capella with COAST at Two Epochs," by J.E. Baldwin, M.G. Beckett, R.C. Boysen, D. Burns, D.F. Buscher, G.C. Cox, C.A. Haniff, C.D. Mackay, N.S. Nightingale, J. Rogers, P.A.G. Scheuer, T.R. Scott, P.G. Tuthill, P.J. Warner, D.M.A. Wilson, R.W. Wilson, p. 13

For years radio astronomers have combined data taken from widely separated antennae to form images with resolutions greater than those obtained with any one antenna. A group at the University of Cambridge in England have used an array consisting of three modest-sized optical telescopes to obtain the first high resolution synthetic aperture images at near-infrared wavelengths. Called COAST (Cambridge Optical Aperture Synthesis Telescope), this telescope array was used to produce images that clearly resolved the close spectroscopic binary star called Capella. The two images taken 15 days apart clearly show the orbital motion previously derived by other indirect means.

This experiment demonstrated that the synthetic aperture techniques used by radio astronomers can be successfully applied to optical wavelengths. While COAST is limited to observing relatively bright targets, larger arrays with bigger telescopes should one day be able to resolve details on the surfaces of nearby stars as well as more distant targets of astrophysical significance. Using arrays of telescopes of sufficient size it should prove possible to directly image extrasolar planets circling nearby stars and eventually search for small terrestrial Earth-like planets.

"SETI at the Spin-Flip Line Frequency of Positronium," by R. Mauersberger, T.L. Wilson, R.T. Rood, T.M. Bania, H. Hein, and A. Linhart, p. 141

SETI practitioners are constantly searching for "magic" frequencies where ETIs may place a beacon for us to find. In the late 1970s, Soviet SETI pioneer Nikolai Kardashev suggested that one such magic frequency might be the 203 GHz spin-flip line of positronium. Positronium is considered by some to be the simplest "atom" consisting of an electron and anti-electron (or positron) circling one another. Positronium comes in two varieties: Para-positronium consists of an electron and positron with spin vectors pointing in the same direction while orth-positronium's particles spin in opposite directions. If during its sub-microsecond lifetime (when the particles meet and annihilate each other) the spin vectors flip from the former state to the latter, a quanta of energy in the millimeter wavelength band is emitted.

This paper describes the results of a targeted search performed at this magic frequency using the 30-meter IRAM telescope. Observations were made of 17 targets chosen because their previously noted excess infrared emissions could indicate the presence of waste heat from a power-rich technological civilization. The data were taken with a resolution of 9.7 kHz and were Doppler corrected to a frame of reference tied to the cosmic microwave background. Unfortunately no unusual signals were detected above the background noise level indicating the absence of omni-directional transmitters with powers on the order of 10^{15} Watts.

March (II) 1996, Volume 307

"Dust Distribution in Disks Supplied by Small Bodies: Is the β Pictoris Disk a Gigantic Multi-Cometary Tail?," by A. Lecavelier des Etangs, A. Vidal-Madjar, and R. Ferlet, p 542

June (II) 1996, Volume 310

"The β Pictoris Circumstellar Disk XXI: Results from the December 1992 Spectroscopic Campaign," by A.-M. Lagrange, F. Plazy, H. Beust, D. Moullet, M. Deleuil, R. Ferlet, J. Spyromilio, A. Vidal-Madjar, W. Tobin, J.B. Hearnshaw, M. Clark, and K.W Thomas, p. 547

Based on a detailed analysis of the now famous disk of dust surrounding β Pictoris, this multinational team of astronomers has concluded that this star is likely surrounded by a swarm of cometary bodies a few kilometers in diameter and possibly an additional larger body. This pair of papers details the team's continuing observation program in which images and spectra are

used to map the distribution, size, and velocity of the dust particles in the disk. These astronomers have shown that the disk can be thought of as a gigantic cometary tail produced by the evaporation of an enormous swarm of comet-like bodies. The presence of a high-velocity population of dust particles along with the previously discovered warping of the disk of dust also hints at the presence of a larger, possibly planetary, body in this system. Although the observations and interpretation of the data need to be confirmed, these conclusions bode well for the presence of comets (which may supply chemicals important to life of forming planets) in other solar systems.

Astronomy & Astrophysics Supplement Series

May (I) 1996, Volume 115

"GAIA: Global Astrometric Interferometer for Astrophysics," by L. Lindegren and M.A.C. Perryman, pp. 579-595

This paper describes the potential science that may be performed with the space-based GAIA astrometric interferometer proposed as part of the European Space Agency's Horizon 2000 Plus program. While there are numerous astrophysical applications for the high accuracy positioning data this system could generate, it can also provide important information on the planets that circle other stars. As currently proposed, this system would be capable of monitoring 50 million stars to 2 to 20 microarc second accuracy for perturbations caused by orbiting planets. In theory this system could detect perturbations caused by Jupiter-sized planets orbiting stars out to 30 to 100 parsecs. Observations of the several to one hundred thousand stars that exist in this volume would give us comprehensive statistics on the size and distribution of extrasolar giant planets in our part of the galaxy.

The Astrophysical Journal

March 20, 1996, Volume 460

"What Planetary Nebulae Can Tell Us About Planetary Systems," by Noam Soker, pp. L53-L56

In this paper the author has examined the statistics of the shapes of planetary nebulae to determine the degree to which their progenitors have been tidally spun up by close, unseen companions. With this information, he has been able to determine the prevalence of brown dwarfs and massive Jovian planets in these systems, as well as the maximum distance of the closest one. The presence of these bodies is thought to be necessary by some since they may act as cometary "shields" for potentially habitable planets in these systems. While some investigators have been worried by the lack of Jupiter-sized bodies discovered so far around sun-like stars (and prematurely so in the opinion of this reviewer), Soker concludes that the arrangement and distances of the gas giants in our solar system is typical for stars with masses ranging as high as 5 $M_{\odot}$.

Icarus

February 1996, Volume 119

"The Stability of Multi-Planet Systems," by J.E. Chambers, G.W. Wetherill, and A.P. Boss, pp. 261-268

Much work has been performed in the past to examine the stability of two-planet solar systems. In this paper the authors examine the orbit stability issue for systems containing three or more planetary bodies. The authors are primarily concerned with the dynamics involved in the planetary formation process which, in later stages, requires the accretion of many lunar-to-Mercury sized bodies to form the larger terrestrial planets. If these planetary embryos settle into stable orbits too quickly, the planetary formation process will cease prematurely leaving a solar system with many small planets and few, if any, Earth-sized terrestrial planets.

The quantitative results discussed in this paper show that the situation with multi-planet systems is much different than what occurs in systems with only two planets. They show that orbital instability alone can explain the creation of very large protoplanets over reasonable time scales. Additional mechanisms must also come into play, however, to complete the process of forming Earth-sized planets in astronomically short periods of time. The physics presented here also has a bearing on the relative stability of solar systems after the formation process has completed.

April 1996, Volume 120

"On the Search for Extant Life on Mars," by Harold P. Klein, pp. 431-436

Twenty years ago the Viking spacecraft's biological experiments returned ambiguous results that, when combined with other information on Martian surface conditions, have generally been interpreted to mean that Mars is currently lifeless. However it is possible that isolated oases exist on Mars, where conditions are much more favorable. In this paper Klein examines the current evidence and argues in favor of the possibility of extant life on Mars. He presents a proposal for continuing this search first by surveying for potentially promising sites using remote sensing techniques from orbit followed by in situ observations and sample returns from these locations. While the Viking results were less than promising, enough uncertainty exists to warrant continuing the search.

Journal of the British Interplanetary Society (JBIS)

April 1996, Volume 49, Number 4

Subtitled "Practical Robotics for Interstellar Missions," this issue of *JBIS* is the second part of a series dedicated to this topic (the first part was published in January 1996 and reviewed on page 22 of the Volume 2, Number 2 issue of *SETIQuest*). A half dozen papers are presented here the most interesting of which is "Nearby Solar-Type Stars as Candidates for Interstellar Robotic Missions" by Alan Hale. As the title implies, the author examines the 45 single and 25 binary systems within 12.5 parsecs of the Sun that contain sun-like stars. He also presents recommendations for near-term investigations as well as an outline of current work being performed at the Southwest Institute in New Mexico with which the author is affiliated. A rather novel interstellar spacecraft concept is also examined in the paper "Hydrogen Ice Spacecraft for Robotic Interstellar Flight". Jonathan Vos Post discusses the concept of an autophage or self-consuming ship where the structure of the ship, which is composed of solid hydrogen ice, can serve as fuel for the spacecraft's own fusion engines. Such a spacecraft can achieve incredibly low dead-weight fractions and vastly increase the performance of an interstellar spacecraft.

Other paper presented in the issue of JBIS include:

"Cost Considerations for Interstellar Missions," by Dana G. Andrews

"A Survey of Micro-Actuator Technologies for Future Spacecraft Missions" by Roger G. Gilbertson and John. D. Busch

"Radioisotope Sails for Deep Space Propulsion and Power" by Robert L. Forward

"Telecommunications, KLT and Relativity" by Claudio Maccone

Marsbugs: The Electronic Exobiology Newsletter

June 4, 1996, Volume 3, Number 3

"On the Realism of Interstellar Travel," by Gerald David Nordley

This issue of *Marsbugs* is devoted to a discussion of interstellar travel. In this particular article, the author counters the arguments made by "people with vested interests in radio SETI" on the futility of physical contact. Nordley, who was an astronautical engineer in the U.S. Air Force, thoughtfully examines the engineering issues involved in interstellar travel and weighs the merits of the various technologies available. He concludes that the pessimistic view of interstellar travel is unfounded and that such ventures could be possible in the next 50 to 100 years.

Nature

April 18, 1996, Volume 380

"Orbital Migration of the Planetary Companion of 51 Pegasi to its Present Location," by D.N.C. Lin, P. Bodenheimer, and D.C. Richardson, pp. 606-607

This brief paper describes a possible scenario to explain the origin of the Jupiter-sized planet closely orbiting 51 Pegasi. These arguments are also applicable to a similar planet recently found orbiting ρ (1) Cancri. Current theories of planet formation predict that Jovian planets should form no closer than 5 AU from their sun. The authors theorize that under the proper conditions, angular momentum is transferred from the inner disk to the newly formed gas giant then to the outer portions of the disk.

As a result of this transfer, the inner disk and the newly formed giant planet start to spiral in towards their sun while the outer disk spirals out. Slowly the inner disk is consumed by the sun as it continues to spiral in. After the inner disk disappears and with the help of additional tidal interactions, the orbit of the migrating giant planet finally stabilizes close to its sun. If this scenario proves to be true, any potentially habitable terrestrial planets in these systems would be destroyed. While at this time this class of planets appears to be relatively uncommon, it may remove a small percentage of sun-like systems from the list of potential homes to extraterrestrial life.

May 2, 1996, Volume 381

"Synthesis of Long Prebiotic Oligomers on Mineral Surfaces," by James P. Ferris, Aubrey R. Hill Jr., Rihe Liu, and Leslie E. Orgel, pp. 59-61

Current theories on the origin of life hold that the precursors of biologically important molecules formed in the ocean where they were slowly assembled into more complex forms. Unfortunately this water-based polymerization process cannot produce molecules consisting of more than 10 monomers which is far below the 30 to 60 monomer molecules thought to be necessary for a viable genetic system. To create these longer, biologically more interesting polymer chains, scientists have proposed that some sort of catalyst must be needed to create the required molecules from the existing soup of smaller units.

In this paper the authors describe their experiments to produce longer polymer chains using common mineral surfaces as a catalyst. They found that if a solution of short oligomers is repeatedly splashed onto certain mineral surfaces and allowed to dry, they could eventually produce molecules up to 55 monomers long. In addition the investigators found that different minerals helped to produce different families of organic chemicals. This experiment tended to produce nucleotides in the presence of montmorillonite while illite and hydroxylapatite induce the formation of amino acids. It now appears that minerals present on the primitive Earth may have provided a veritable library of surfaces for the exploration of molecular evolution that ultimately led to the development of life.

The Planetary Report

May/June 1996, Volume 16, Number 3

"The Search for Extraterrestrial Intelligence: Scientific Quest or Hopeful Folly?," by Ernst Mayr and Carl Sagan, pp. 4-13

This article is a debate between Ernst Mayr and Carl Sagan who hold opposing positions on the question of the existence of extraterrestrial intelligence (ETI). Mayr believes that while there may be other habitable planets in our galaxy, each successive step in the evolution towards technically capable intelligence is increasingly improbable, making it highly unlikely that technological civilizations other than our own exist. Not surprisingly, Carl Sagan takes the opposite position, arguing for the inevitability of the existence of ETI given the large number of worlds in our galaxy where it can evolve.

The article takes the form of a debate in which first Mayr then Sagan present their central arguments in individually written articles about three pages long each. In the remaining three pages they respond to each other's arguments and counter-arguments. The article is definitely worth reading because it debates the central issues for and against the existence of ETI.

The Proceedings of the 27th Annual Lunar and Planetary Conference

Held March 18 to 22, 1996

"Nonaxisymmetry in the Solar Nebula: Disk Evolution or Giant Gaseous Protoplanet Formation?," by A.P. Boss, p. 141

In this paper the author presents the results of a 2D hydrodynamical model of a symmetric protoplanetary disk with a mass of 0.14 $M_{\odot}$. He shows that after only 100,000 years the outer portion of the disk cools enough to become gravitationally unstable. The growth of this nonaxisymmetry quickly grows in amplitude and results in the formation of two Jupiter-mass clumps of gas at a distance of about 8 AU. At the same time the hotter inner portions of the disk remain symmetric and stable.

This model supports many astronomers' "best of both worlds" view that gas giants will form in the unstable, cool outer portions of a solar disk while allowing for the formation of terrestrial planets in the hot inner portions of the disk. This adds weight to the common belief that the arrangement of planets in our solar system is typical while the recently discovered solar systems with

large planets close to their suns are the relatively rare exceptions to the rule.

"The Effect of Ultraviolet Radiation on Planetary Habitability," by J.F. Kasting, D.C.B. Whittet, and W.R. Sheldon, p. 655

These days with the threat to the ozone layer that blankets our planet, even the lay public is aware of the need of stratospheric ozone to protect life from the Sun's ultraviolet radiation. While the mechanism of ozone formation is understood with sun-like G stars, it was not certain if enough ozone would form on potentially habitable planets orbiting stars of other types. Cooler K stars might not produce enough ultraviolet light to form an ozone layer thick enough to protect a planet from what little ultraviolet radiation these stars produce. In hotter F type stars which produce much more ultraviolet radiation, it was feared that the harmful radiation will out strip a planet's ability to form protective ozone. In either case, otherwise habitable planets could be rendered sterile due to excessive ultraviolet rays.

In this paper the authors present detailed calculations that show this not to be the case. Instead they demonstrate that planets orbiting in the habitable zones of F or K stars are better protected from the harmful effects of ultraviolet light than are planets like ours orbiting G stars. The highly non-linear ozone formation process results in ozone production in excess of the minimum needed to shield the surfaces of habitable planets circling these types of stars.

"Habitable Planets with High Obliquities," by D.M. Willaims and J.F. Kasting, p. 1437

For more than a third of a century it has been assumed that planets with axial tilts in excess of about 55 degrees would be unsuitable for life. This is because the high obliquity would result in intolerable temperature swings as large portions of a planet alternately experienced perpetual light and darkness over the course of a year. Since it is now generally believed that the unlikely presence of a large moon is needed to stabilize a terrestrial planet's obliquity at tolerable levels, it is beginning to appear that habitable planets might be rarer than once thought. In this paper the authors present arguments that this 55 degree limit may not be as inviable as once believed.

The authors examine the results of detailed simulations demonstrating that the temperature extremes caused by high obliquity can be mitigated by the presence of a dense atmosphere of carbon dioxide. With a thermal inertia greater than what is found in the relatively thin atmosphere of the Earth, these denser atmospheres heat up and cool down less quickly thus evening out the temperature extremes. Planets with the required dense atmospheres of carbon dioxide would be found towards the outer portions of a star's habitability zone. This is due to the climate stabilizing carbonate-silicate weathering cycle that will pump more carbon dioxide into the atmosphere to maintain the temperature above freezing at these more extreme distances.

Science

May 10, 1996, Volume 272, Number 5263

"The Galileo Probe Mass Spectrometer: Composition of Jupiter's Atmosphere," by Hasso B. Niemann, Sushil K. Atrreya, George R. Carignan, Thomas M. Donahue, John A. Haberman, Dan N. Harpold, Richard E. Hartle, Donald M. Huten, Wayne T. Kasprzak, Paul R. Mahaffy, Tobias C. Owen, Nelson W. Spencer, and Stanley H. Way, pp. 846-849

This paper is one of several appearing in this issue of *Science* giving the preliminary findings of what the Galileo probe found during its long awaited descent into the Jovian atmosphere on December 7, 1995. In this paper the initial findings of the mass spectrometer are summarized. Surprisingly, less than one tenth of the previously expected amount of water was detected. At first it appeared that this might have been due to the fact that the probe entered into a relatively uncommon region with a warm, dry atmosphere. The unlikely required circumstances involving the planet's circulation and extreme down drafting combined with findings from the radio science occultation experiment (which are not discussed in this issue) seem to make this explanation untenable. Some mechanism seems to have globally reduced Jupiter's abundance of water. Also not detected were organic compounds more complex than methane. Taken together, it seems unlikely that Jupiter, and possibly gas giants in general, are capable of supporting life as we know it.

Scientific American

April 1996, Volume 274, Number 4

"Search for Life on Other Planets," by J. Roger P. Angel and Neville J. Woolf, pp. 60-66

This popular-level article gives an excellent review of a proposed space-based system to directly image and perform spectroscopy on extrasolar planets as small as the Earth. The authors take the reader step by step through the operation of this infrared instrument to show how it can interferometrically cancel the blinding glare of a solar system's sun, revealing the relatively dim planets that circle it. A variety of distinctive absorption bands exists in the infrared region of the spectrum where the telescope operates, allowing the detection of many biologically important gases such as carbon dioxide, water, and ozone, just to name a few. While this proposed 50 to 75-meter-long device will not be operating until well into the next century, intermediate steps leading to its development should be indispensable in learning more about the extrasolar planets already discovered as well as finding new ones circling our neighbors.

Spaceflight

April 1996, Volume 38, Number 4

"Project SERENDIP: The Search for Extraterrestrial Intelligence (SETI)," by Jordi L. Gutierrez, pp. 122-123

This article gives a brief overview of the history of Project SERENDIP. The most current incarnation of this program, SERENDIP III, is a "parasitic" SETI project that uses the giant radio antenna near Arecibo, Puerto Rico, while the main antenna feed is used for other radio astronomy projects. While it is not aimed in any way, this 4 million channel system, operating at 430 MHz, manages to sample most of the sky visible to the antenna at least once and sometimes as many as five times over the course of a year. At this time SERENDIP IV is being designed and built and promises to scan 167 million channels with some telescope time dedicated to observing interesting signals previously detected.