COMMISSION 51: BIOASTRONOMY (BIOASTRONOMIE)
Report of Meetings, on 25,26,30 July 1991

PRESIDENT: George Marx VICE-PRESIDENT: Ron Brown
SECRETARY: Jean Heidman

26. July 1991: Business meeting

Commission 51 deals with scientific problems related to Bioastronomy, including discussions concerning the emergence of life and intelligence in the Universe, designation of the promising sites, empirical search for life and technology, finally the possible connection of the terrestrial life to astronomical factors. This Commission was formed at the iniciative of Michael Papagiannis (Boston University) in 1982 and it worked under the chairmanship of Michael Papagiannis, Francis Drake and George Marx since then. The Commission counts well above 300 members from astronomy and interdisciplinary fields. Members of the Commission were reached by the Bioastronomy News, edited by Michael Papagiannis. The president of the Commission 51 reported about the activities as follows:

Meetings on Bioastronomy at the IAU General Assemblies were well attended by the members of IAU (beyond the membership of the Commission 51), and by invited experts from other sciences since 1979. This proves that the interdisciplinary approach of our Commission corresponds to a definite need. The advances of our scientific understanding of planet and comet formation, the exploration of the Solar System by space probes, the empirical and theoretical investigation of the planetary atmospheres, the clarification of the early history of our own planet, the confrontation of astronomical and geological evidences with the laboratory experiments concerning chemical evolution, the grand theories of the origins of life based upon our most recent scientific knowledge, finally the spectacular advances of radio astronomy due to the fast development of computer technique made bioastronomy to a solid and respected branch of research in the 1980-es. This explains the increased interest of the scientific community and funding agencies.

Members of the outgoing Organizing Committee of IAU Commission 51 (1988-1991) were George Marx, president (Hungary), Ronald D. Brown, vice-president (Australia), Michael Papagiannis, founding president and present secretary (U.S.A.), furthermore Frank Drake, past president (U.S.A.), Bruce Campbell (Canada), Samuel Gulkis (U.S.A.), Jun Jugaku (Japan), Jean Heidman (France), Nikolai Kardashev (Soviet Union), V.I. Slysh (Soviet Union), Jill C. Tarter (U.S.A.).

The members of the incoming Organizing Committee (1992-1994) are Ronald D. Brown, president (Australia), Jill C. Tarter, vice-president (U.S.A.), Jean Heidman, secretary (France), Michael Papagiannis, past president and editor for Bioastronomy News (U.S.A.), Frank Drake, past president (U.S.A.), George Marx, past president (Hungary), furthermore Bruce Cambell (Canada), F. Colomb (Argentina), H. Hirabayashi (Japan), Mike Klein (U.S.A.), S. Slysh (Soviet Union).

The highlights of the first decade (1982-1991) of IAU Commission 51 were the Bioastronomy Symposia in Boston (U.S.A., 1984), at Balaton (Hungary, 1987) and in the Alps (France, 1990). These were well attended by about 100 experts from the fields of planetary

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astronomy, radio astronomy, geology, climatology, organic chemistry, biochemistry, basic biology and psychology. Prominent astronomers joined the symposia of the Commission who considered the place and role of life a question worth of special interest.

The Third Bioastronomy Symposium was organized by Jean Heidman (radio-astronomer, Paris), in Val Cenis, at the heart of the French Alps in July 1990. The programme of the conference was designed by Michael Klein (Jet Propulsion Laboratory, U.S.A.). The Proceedings of the Third Bioastronomy symposium is edited by Jean Heidmann and is printed by the Springer Verlag. – The discovery of the infrared excess related to main sequence stars, the sighting of circumstellar dust disks and the study of periodic variation in the Doppler shift of stellar spectra strengthened our conviction in the abundance of planetary systems. The study of interstellar molecular clouds, the missions to comets, the observation of bombardment of the terrestrial atmosphere by ice meteorites contributed to the empirical knowledge of chemical evolution in space. Comparative studies of the atmospheric chemistry of Venus, Mars, Titan and the reconstruction of the early terrestrial atmosphere indicated the initial conditions for the emergence of life. Finally, the spectacular advances of electronics made the scanning of sky for signals indicating advanced extraterrestrial technology more economic and promising than ever since the first venture of Frank Drake. – At the 30th anniversary of Project Ozma friends and followers greeted Prof. Frank Drake in Santa Cruz in November 1990.

The Commission 51 discussed and unanimously supported the Declaration of Principles concerning activities following the detection of extraterrestrial intelligence, formulated by the International Academy of Astronautics, and proposed its acceptance to the International Astronomical Union. – The proposal for the creation of global information network for the Search of Extra terrestrial Intelligence (SETI) was accepted, and Jean Heidman (Observatory of Paris) was charged with its organization.

The Symposia of IAU Commission 51 were not the only activities in the field of bioastronomy. The Planetary Society organized an international SETI conference in Toronto (1988). The International Academy of Astronautics has a Committee on Search for Extraterrestrial Intelligence, headed by John Billingham, Ivan Almar, Jill Tarter, and it keeps close contact to Commission 51 of IAU. They organized SETI sessions in Bangalore (1988), Torremolinos (1989), Dresden (1990) and they cosponsored the Third Symposium on Biosatronomy (1990).

The activity in search for extraterrestrial intelligence will speed up in the 1990es. Argentina, the host country of this General Assembly will establish the first SETI dedicated facility for the Southern Sky under the direction of F. Colomb, in cooperation with the Planetary Society. NASA launches two major SETI programs: a targeted search (directed by NASA Ames) and an All-Sky-Survey (directed by the Jet Propulsion Laboratory). The intended starting day is 12 October 1992, the 500th/a Anniversary of landing of Columbus in the New World. The planned location of the 4th Bioastronomy Symposium is understandably: California, 1993.

25. July 1991: Astronomical Impacts on Life and Extinction

George Marx (Budapest, Hungary): Astrophysics, Climate, Technology. The inner planets of the Solar System (Venus, Earth, Mars) started evolving under very similar conditions but only the Earth has been able to develop an atmosphere sustaining liquid water through billions of years, what is a prerequisite for biological evolution. This raises the question about the nature of the terrestrial thermostat and its stability against external and internal impacts. Understanding this problem is of vital importance for the anticipation of future variations in the terrestrial climate, what is nowadays under attack by human industrial releases.

David Schwartzmann (Washington D.C., USA): The Relative Stability of the Biosphere Geophysiology. A recognition of the role of biota in the enhancement of chemical weathering on the Earth's continents leads to important consequences:

1. The habitability of Earth is a result not only of geochemistry but geophysiology. Were it not for microbial enhancement of weathering, surface temperature on Earth would have remained fit only for thermophilic bacteria (>50°C).

2. The transition from an abiotic to biotic surface was followed soon after by colonization of land by thermophilic bacteria, leading to sharp reduction in CO_2 and temperature, opening up the possibility of the evolution of low-temperature life.

3. The global surface temperature hovered near 20°C as a result of microbal and higher plant amplification. Leaving aside human intervention, temperatures will climb above 50°C in 3 billion years, appropriate only for thermophilic bacteria.

4. The geophysiological climatic regulator is a necessary condition for the evolution of complex life including intelligence around other sun-like stars.

Mikio Shimizu (Kanagawa): Water planet Earth should selects Nucleic Acid. Nucleic acid bases were selected for the terrestial life by water, which characterized the planet Earth in the Solar System. In water, two (hydrophobic) nucleotides stack in order to decrease the area in contact to water. (In contrast, two nucleotides make strong Watson-Crick type hydrogen bonds in a hydrophobic solution such as chloroform or benzene.) Under this conformation, the positions of the hydrogen bond aceptors and donors are uniquely determined to be able to recognize some biomolecules, other bases or amino acids.

L.R. Doyle (SETI Institute, USA): Astrophysical and Planetary Constraints on Exobiological Habitats. Liquid water seems to be essential for the origin and evolution of biology around a star. The ecospheric zones in the Solar System are present Earth, early Mars, possibly the Jovian moon Europa, and speculatively early large cometary nuclei. The heating source for the Earth and early Mars is solar flux, complemented by atmospheric green house warming. Tidal heating of Europa, caused by the pumping of its orbital eccentricity by the other outer satellites could possibly maintain a liquid water environment a few kilometers below the ice surface. In addition, radiogenic heating of cometary interiors by ^{26}Al may have also maintained a liquid water environment for an exobiologically significant time period. – The cratered terrain runoff channels on early Mars indicate large amounts of liquid water existing there, yet recent attempts to create such an environment have run into difficulties with CO_2 condensation. A reexamination of the standard early

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solar model may be necessary requiring early solar mass loss (one of the explanations for the solar lithium depletion.)

C.N. Matthews (Chicago): Life and Death from Comets. In the presence of a base such as ammonia, liquid HCN (bp 25°C) polymerizes spontaneously at room temperature to a black solid. The polymers are stable ladder structures with conjugated =C=N– bonds, and polyamidines are readily converted by water to polypeptides. These macromolecules, so easily formed in a reducing environment, could be major components of the dark matter observed on many bodies in the outer Solar System. The nonvolatile black crust of comet Halley may consist largely of such polymers. HCN polymers are the dark bearing solids identified spectroscopically in the dust of new comets, on the surfaces of several asteroids of spectral class D, within the rings of Uranus, and covering the dark hemisphere of Saturn's satellite Iapetus. HCN polymerization could account also for the yellow-orange-brown coloration of Jupiter and Saturn, as well as for the orange haze high in Titan's atmosphere. – Direct evidence for the extraterrestrial presence of HCN polymers may be in hand if mass extinctions of life were brought about by bolide impacts, particularly during the Cretaceous/Tertiary period 65 million years ago. The alpha-amino acids detected in such boundary regions, presumably imported by comets or meteorites, may well be hydrolysis products of cyanide polymers.

I. Almár (Budapest): Supernovae, Co-rotation, Life. Since both supernovae and giant molecular clouds are concentrated in spiral arms, the motion of the Solar System with respect to the spiral arms of the Galaxy is crucial. According to Balázs, Marochnik and Mukhin, Sun is near the co-rotation circle, there would be no crossing of any spiral arm during the lifetime of Earth.

C.A. Olano (Buenos Aires): Encounters with Giant Interstellar Clouds. These might be the prime motors in the catastrophic extinctions of species. Such encounters can perturbe the Oort cloud to induce comet showers. The past galactic paths of the Sun and molecular clouds have been traced, taking into account the gravitational perturbations of the Sun's orbit by giant clouds. The Sun passed near Ori OB1 around $1.5{\cdot}10^7$ years ago and near Mon OB1 around $3.4{\cdot}10^7$ years ago, in approximate correspondence with the dates of the Miocene and the major Eocene mass extinctions.

M.D. Papagiannis (Boston): Impacts, Mass Extinctions and the Nemesis Hypothesis. Life may help to avoid a run-away glaciation or run-away greenhouse-effect, which respectively have made Mars and Venus uninhabitable. Impacts of meteors (asteroids, comets) may produce dust clouds, resulting in stopping of photosynthesis and global drop of temperature, what might result in mass extinction. Evidence for such K/T impact was found recently on the Yucatan peninsula. The highly excentric orbit of the hypothetical dwarf star Nemesis may explain periodic extinctions: by distrubing the cometary belt, it can cause cometary showers on Earth, supplying organics and causing "cosmic winters".

F. Graham-Smith (Jodrell Bank, UK): The Discovery of a New Planet. The first new planet outside the Solar System has been found by the radioastronomers Andrew Lyne, Matthew Bailes and Setnam Shemar. The survey of the galactic plane by the 76-metre Lovell radio telescope revealed 40 new pulsars. They fitted previous models of solitary or binary systems but PSR 1829-10, with a period of 0.330s. Observations extending over three years show that the arrival times of the pulses vary by 0.008s sinusoidally with a period of 184 days. This corresponds to the motion of a neutron star with a mass of 1.4 solar masses under the gravitational pull of a 10 Earth-mass planet at a distance of 0.7 A.U. – The measured period derivative of the pulsar gives the characteristic age of 1.25 million years. The origin of the planet is the subject of speculation. The standard scenario of red giant followed by Type II supernova would disrupt any planetary system. An accreting white dwarf may have collapsed to a neutron star, the collapse being slowed down by the same rapid rotation that formed a disk producing the planet. The excentricity of the planetary orbit is less than 0.05, what can be explained by interaction with the disk.

30 June 1991: Search for Extraterrestrial Technology

Steven J. Dick (U.S. Naval Observatory): Bioastronomy–Birth of a New Scientific Discipline. Since the dawn of the Space Age four research specialties have converged to form the new discipline of Bioastronomy: planetary science, planetary systems science, origin of life studies and the search fore extraterrestrial intelligence (SETI). Bioastronomy is being institutionalized by meetings, recognition in international societies and funding from several sources, but a journal unique to the discipline is still lacking.

M.D. Papagiannis (Boston): Tritium Line May Reveal Alien Observing Stations. The nearest civilization may have detected the presence of oxygen in our atmosphere, which is indication of life, and may have dispatched an automated probe to our Solar System to keep them informed about developments on our planet. The space station may get energy; nuclear fusion of deuterium into helium, a by-product of which is tritium. Tritium has a short half-life, therefore its existence in significant amounts would indicate the presence of a nuclear fusion plant in our solar system. Valdez and Freitas searched for tritium in 53 nearby stars. They did not search, however, for tritium in our Solar System, what we hope to do with the radio telescope at Green Bank.

Ivan Almar (Hungary): Selecting targets of both astrophysical and dynamical interest. Several authors have suggested that astrophysically improbable objects like blue stragglers, Ap and carbon stars are modified by advanced civilizations. According to Balázs, Marochnik and Mukhin only stars in a narrow zone around the co-rotation circle had time long enough to develop ETI. Therefore all stars modified by astroengineering activity must have a strong concentration near $l = 90^o$ and 270^o. Although there is some deficiency of N and S stars near the direction of the galactic center, the real distribution function is different from what has been derived from the "belt of life" hypothesis.

Fernando R. Colomb (Buenos Aires): SETI Activities in Argentina. Since October 12, 1990, META II is observing the southern sky. It uses a 30 m radiotelescope of the Instituto Argentino de Radioastronomia (IAR) during 12 hs. a day, to cover all the sky south of -10^o at the frequency of the 21-cm HI line. Successive spectra of 400 KHz at 0.05 Hz resolution are searched for features characteristics of a narrowband beacon transmission. META II was built at Harvard University by J.C. Olalde and E. Hurrell under the direction of P.Horowitz and with funds provided by The Planetary Society.

Stuart Bowyer, Dan Wertheimer, Chuck Donnelly, Michael Lampton(Berkeley): Recent Results and Progress on SERENDIP III. The SERENDIP project is an ongoing program of monitoring and processing broadband radio signals acquired by existing radio astronomy observatories. SERENDIP operates in a piggyback mode: it makes use of whatever observing plan is under way at its host observatory. The data acquisition system operates autonomously. This approach makes is possible to obtain large amounts of high quality observing time in a manner that is economical. The SERENDIP II system monitored some 64 000 channels simultaneously and was installed at the NRAO 3300-foot telescope at Green Bank. It was operated there for two years until the collapse of that telescope. SERENDIP III will monitor more than 4 000 000 channels simultaneously.

John Whiteoak (Australia): SETI Activities in Australia. Observations with the Parkes Radiotelescope. A group of scientists from the University of Western Australia, Division of Radiophysics CSIRO, and Australia Telescope National Facility CSIRO, have used the 64-m radiotelescope at a frequency of 4.46GHz to search for narrow spectral-line emission from selection of stars and globular clusters. Null results are used to estimate an upper period of 100 million years for extraterrestrial civilizations trying to make contact.

Kent Cullers (NASA Ames): Targated Search Signal Detection from Theory to Practice. NASA's Targeted Search for Extraterrestrial Intelligence examines narrowband data for evidence of drifting continuous and pulsed sinusoids. The pulsed sinusoidal signals are sought from approximately 1Hz to 30Hz in octave steps. The Targeted Search Signal Detectors process the multiple resolution output of the MCSA, a 10 MHz spectrometer with about 14 million channels at each of six resolutions. Development of efficient pulse detection and CW path accumulation algorithms allowed computation rates to drop into the range of commercially available hardware. Current plans are expected to result in the first full signal detector implementation late this year. The pulse detector is being developed at NASA-Ames. It uses a parallel architecture. Its heart is the 1860 processor.

S. Gulkis, D.J.Burns, C.Foster, M.F.Garyantes, M.J.Klein, S.Levin, E.T.Olsen, H.C. Wilck, and G.Zimmerman (JPL): Status of the NASA SETI Sky Survey. The primary objective is to search the entire sky over the frequency range 1GHz to 10GHz for evidence of narrow band signals of extraterrestrial, ingelligent origin. A frequency resolution near 20Hz will be used across the entire band. A spectrum analyzer with upwards of the million channels will be used to keep the survey time to approximately six years. Data rates in excess of 10 gigabits per second will be generated in the data taking process. Sophisticated data processing techniques will be required to determine the ever changing receiver baselines, and to detect and archive potential SETI signals. Existing radio telescopes, including several of NASA's Deep Space Network (DSN) 34 meter antennas located at Goldstone, CA and Tidbinbilla, Australia, will be used for the observations. The Jet Propulsion Laboratory in Pasadena, California, has the primary responsibility to develop and carry out the Sky Survey. – In order to lay the foundation for the full scale SETI Sky Survey, a prototype system is being developed at the Jet Propulsion Laboratory. This system will be used to provide a proof of concept model for the Sky Survey observing project. It will used to test and refine real time signal detection algorithms, to test scan strategies and observatory control functions, and to test RFI rejection schemes.