SEEKING BEHIND THE ANTHROPIC PRINCIPLE

AUTHOR: Ana I Gómez de Castro
INSTITUTION: Universidad Complutense de Madrid
ADDRESS: Fac. CC Matemáticas, Universidad Complutense de Madrid
Plaza de Ciencias 3, 28040 Madrid, Spain
E-mail: aig@mat.ucm.es
Phone: +34-913944058

The Universe must have the properties which allow life to develop within it at some stage.

Our Universe is but one of many possible worlds. For humans to exist, a remarkable fine tuning of the laws of physics and the fundamental constants is required. Cosmological models possessing different initial conditions but with the same laws do not necessarily evolve to produce a Universe like ours, 13.7 billion years after the Big Bang. What does produce universes like ours?, which subset of the possible universes allows the emergence and eventual evolution of life?

Astrophysics research has sought actively the answer to these questions though the quest is biased; the *observable* Universe is just the (small) fraction of the actual Universe causally connected to our present.

During the last two decades, some amazing results from this exploration have come up such as the discovery of the Cosmic Web and the anisotropy of the cosmic background or the realization that planetary systems are widespread. Major attempts to reach information from redshifts above six have been implemented yet, the time span from redshift two to present covers about 80% of the life of the Universe. It is in the time frame that life emerges because metals are widespread, the star formation pace has slowed down favoring diffuse star formation where planetary systems can actually survive and the interaction between a rich ultraviolet field and matter accelerates the organic chemistry and creates the environment for complex molecules to survive in planets protected against the harsh space environment.

The anthropic principle is about the emergence of life, of complex and intelligent life. For that, nucleosynthesis needs to have proceeded to enrich significantly the interstellar medium and guarantee that carbon, nitrogen, oxygen and phosphor are widespread in the Universe. Studies of the metal abundance variation up to redshift 5 are showing that the metallicity increases steadily with the age of the Universe. However there are numerous evidences of a large scatter in the metallic properties of matter for any given z; non metal-enriched clouds have been detected and chemically processed material has been found in the voids of the Comic Web. Meanwhile, the star formation rate seems, to be decaying from z=1. Important clues on the metal enrichment spreading on the Universe hang on inter-galactic transport processes such as galactic winds or the effect of galactic interaction in halos that are poorly studied because of the lack of high sensitivity imaging capabilities to detect the warm/hot plasma emission from galactic halos. Current information comes from absorption spectroscopy that it is a rather inefficient technique to map the large scales involved and requires the presence of strong background sources. Moreover, most of the emission is expected to come from filaments and chimneys that will require a high sensitivity imaging capability with resolutions at least ten times better than those provided by the GALEX mission.

Galactic halos are made of collision less plasmas, very sensitive to fields and waves. Thus, they can be used as a good diagnostic tool for variations in the galactic gravitational field, or in more subtle fields as those that might be associated with dark energy.

Metallicity is relevant for life generation not only at the DNA level but also at much earlier phases. Silicates and carbonates are the key building blocks of dust grains in protostellar disks; dust grains get charged by the absorption of UV radiation and their charging profiles depends on the hardness of the spectrum. Solar precursors produce harder radiation fields than massive stars. Extreme UV radiation is a major actor in protostellar disk evolution. It drives to the photoevaporation of the gas compound from the disk releasing the rocky planetesimals for planetary building up. Unfortunately, little is known about the EUV radiation from solar-system precursors. The measurements carried out in X-ray or softer UV bands point out that the EUV flux varied significantly during the pre-main sequence evolution. Protostellar disk were shielded from hard radiation only in the early phases but then, a source of disk ionization must be searched for to guarantee the accretion process.

After 1 million years, protostellar disks are transformed into young planetary disks and the EUV radiation from a very active young Sun heavily irradiates them. The very active stellar winds are expected to interact with the left over particles and produce diffuse Helium and Hydrogen emission that pervades the whole young systems during planets early evolution and planetary magnetosphere formation. Around the Sun, within a modest radius of 140 pc, there thousands of young solar-like stars in all evolutionary stages. A modest spectral resolution instrument to measure the EUV spectra of these sources and compare it with that of our Sun will provide a unique perspective magnetospheres and coronal evolution, as well as on its impact in planetary formation and evolution.

But the study of the last ten billion years of the life of the Universe is also interesting for fundamental reasons. It is in this time lapse that the accelerated expansion of the Universe has been discovered. Moreover, marginal evidence of small variations of the fine structure constant have been reported for redshifts 1.5-2 . The fine structure constant, $\alpha=e^2/\hbar c$, is the parameter that governs the strength of electromagnetism; it couples the electromagnetic field to all charged particles in nature. Unfortunately, measurements are ground-based and subjected to the uncertainties of the atmospheric refraction index that it is a major source of error. The accurate *many multiplet* method makes use of resonance transitions from Fe II and Mg II, radiated in the ultraviolet in the rest frame and redshifted into the optical range by the cosmological expansion. Measurements from space would be much more accurate provided that stable high resolution spectroscopy and a high collecting surface to reach $z=2$ is provided. Also, space opens up the possibility to use stronger multiplets like the Lyman series of Hydrogen.

Behind these measurements resides the basis of quantum physics and the understanding of vacuum fluctuations and energy. Vacuum energy was first hypothesized to model the Lamb shift detected in the Hydrogen atom. Would it be possible to measure the Lamb shift in remote sources, up to redshift 2?. This is a most challenging measurement because not only a very efficient large collecting surface is required but also a complex experimental set-up, difficult to operate in space . Maybe, a Moon-based lab could be set-up to measure the Lamb shift in astronomical sources up to $z=2$.

To conclude, along the path that drives from the Big Bang to intelligent life there are cross-roads, critical steps that made feasible our Universe, some of them are the accelerated expansion, the chemical processing of matter, the metal mixing in the Universe, the interplay between UV radiation and matter to finally produce planets and life. Facilities to detect the UV radiation from the observable Universe up to z=2 are required. The largest discovery potentials are in:

1. high sensitivity, high resolution imaging from 1000 to 4000 Å to map the intracluster medium and galactic halos, chimneys and winds.
2. high sensitivity, high resolution spectroscopy from from 1000 to 4000 Å to measure the evolution of the fine structure constant till z=2
3. low resolution (500-1000) EUV spectroscopy to reach the nearest star forming laboratories at 140 pc to follow the pre-main sequence evolution of magnetospheres and winds in solar-like stars.

Ana I Gómez de Castro – 10th August 2012

I am willing to attend and participate in a workshop if invited