The origin of life

Astrobiology

The study of the origin, evolution and distribution of life in the universe is the groundwork of Astrobiology. This is a multidisciplinary science in which astrophysics, physics, chemistry, biology and geology work in synergy to answer the following questions:

- How did life originate on Earth and how did it evolve?
- Is there life in space and how can we find evidence of it?

There is increasing consensus among the scientific community on the hypothesis that we cannot understand the origin and evolution of life unless our scenario goes far beyond the restrictive limits of our own planet. This new perspective has its foundations on the ever-increasing amount of discoveries of organic molecules in interstellar clouds, and amino acids and other biologically relevant material – i. e. molecules that are commonly found in proteins – in meteorites.

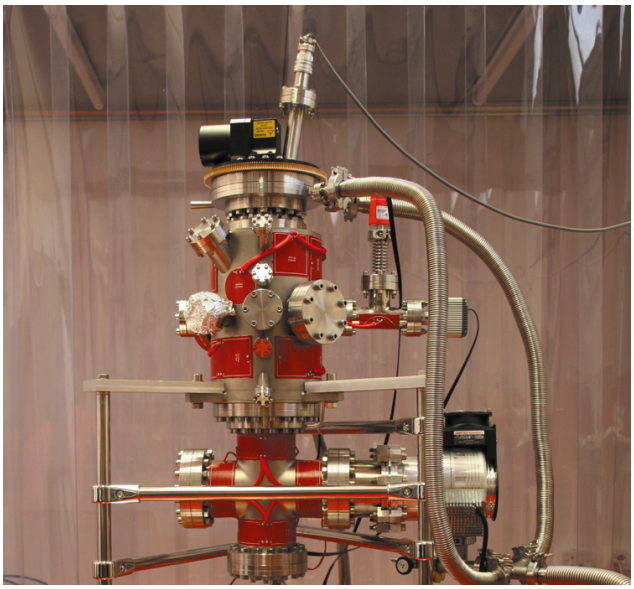
Formation of solar-like planetary systems

Observations and theoretical models suggest that planetary systems like ours came from dense interstellar clouds made of gases and dust particles which, because of gravity, collapsed to form a central star, the planets and a large amount of minor celestial objects such as small grains, meteorites and comets. In the newly formed planetary system these objects intensely bombarded the protoplanets. For instance, over the first 320 million years of its life, matter a thousand times larger than the current mass of our planet, settled on Earth. During this bombarding phase a lot of prebiotic material, fundamental to life, is very likely to have reached Earth. From this hypothesis other questions arise: what kind of processes has led to the formation, in space, of complex molecules such as amino acids? And how could they survive the ionizing solar radiation?

Solar radiation, if on one hand can cause damage to prebiotic material, on the other is crucial in supplying the energy required for the synthesis of prebiotic molecules in interplanetary space. Although several models have been recently proposed to explain amino acid formation in space, we still do not know what role exogenous prebiotic molecules play in the origin-of-life process. Inasmuch as amino acids, and overall prebiotic material, are photodegradable and lack any suitable protective mechanism, it is unlikely that they could have survived in interplanetary space and on Earth which, when life began 4 billion years ago, was devoid of an atmosphere capable of protecting the biologic material from the ionization of solar radiation. So, although the hypothesis that basic life molecules are exogenous is well observed and experimented, it is far from representing a coherent and complete theory for the origin of life.

The OAPa astrobiology laboratory

In 2006 a laboratory for astrobiology was set up, mainly in order to study the involvement of X and UV radiations coming from Sun-like young stars, in the synthesis of organic compounds, particularly amino acids. It is being planned to artificially simulate the interplanetary space conditions by means of a high vacuum room (10^{-13} bar). The room is provided with a pumping system creating and maintaining high vacuum conditions, a cryostat through which 10 K temperatures (about –263 C°) can be reached, X and UV radiations sources simulating emissions from the young sun, and measuring equipment.



High-vacuum room at the OAPa astrobiology laboratory

The experiments carried out until now have tried to ascertain how X- and UV-ray affect the DNA molecules of *Bacillus subtilis* and plain amino acids. Made in conditions comparable to those existing in the terrestrial environment (solutions at room temperature), the experiments have pointed out the role played by the two radiation types and the solvent, and the protecting function of clay on the molecules from the radiation effects. In the future the same experiments will be carried out under space conditions: at cryogenic temperatures and using a solvent with a chemical composition similar to that of the ice covering the dust particles present in the planetary space.