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Atmospheres in a Test Tube

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Abstract

The "Atmosphere in a Test Tube" project is a laboratory experiment that will be able to reproduce condition of extreme environments by means of a simulator. These conditions span from those existing inside some parts of the human body to combinations of temperatures, pressures, irradiation and atmospheric gases present on other planets. In this latter case the experiments to be performed will be useful as preliminary tests for both simulation of atmosphere of exoplanets and Solar System planets and Astrobiology experiments that should be performed by planetary landers or by instruments to be launched in the next years. In particular at INAF Astronomical Observatory of Padova Laboratory we are approaching the characterization of extrasolar planet atmospheres taking advantage by innovative laboratory experiments with a particular focus on low mass Neptunes and Super earths and low mass M dwarfs primaries.

1. Introduction

Space missions, as EChO, or ground based experiments, as SPHERE, have been proposed to measure the atmospheric transmission, reflection and emission spectra over a wavelength range from 0.4 to 11 micron by measuring the combined spectra of the star, its transmission through the planet atmosphere and the emission of the planet. The planet atmosphere characteristics and possible biosignatures will be inferred by studying such composite spectrum in order to identify the emission/absorption lines/bands from atmospheric molecules such as water (H_2O), carbon monoxide (CO), methane (CH_4), ammonia (NH_3) etc. The interpretation of the future EChO observations depends upon the understanding of how the planet atmosphere affects the stellar spectrum and how this last affects the planet emission/absorption. In particular, it is important to know in detail the optical characteristics of gases in the typical physical conditions of the planetary atmospheres and how those characteristics could be affected by radiation induced phenomena such as photochemical and biological one. Insights in this direction can be achieved from laboratory studies of simulated planetary atmosphere of different pressure and temperature conditions under the effects of radiation sources, used as proxies of different bands of the stellar emission.

6. Atmospheres Characterization

At INAF Astronomical Observatory of Padova Laboratory we are going to perform a project to approach the characterization of extrasolar planets atmosphere taking advantage by innovative laboratory experiments aimed at producing a database of simulated planetary atmospheres of low mass panets (Neptunes and Super Eaths) of variable composition, temperature, pressure and density. We'll study their absorption properties as a function of orbital separation and irradiation properties and the impact on such properties due to non equilibrium chemistry such as photochemical and biological process. In particular we undertake photochemistry and photobiology experiments by irradiating organic sample (e.g. bacteria) in presence of gas mixture representative of the atmospheres of Neptunes and Super Earths within a framework of atmospheric content based on the presence of volatiles ([1]). This would allow to gauge the effects of the interaction among organics, atmospheres, and radiation, permitting the identification of specific biomarkers and biosignatures in the atmospheric spectra. The experimental investigation will initially make use of environmental chamber with dedicated atmospheric cells in which the gas mixture as well as the organic materials will be confined in order to be irradiated

and analyzed. Eventually the related effects will analyzed off line in a hermetic cell for measuring the absorption spectra in order to measure the optical constants and then the gas spectrum.

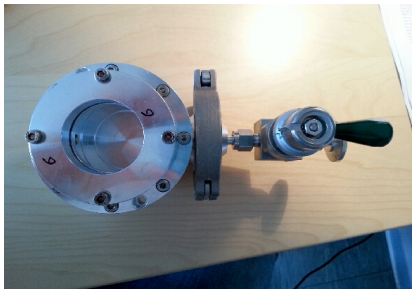

Figure 1: One of the cells where the gas mixture and the biological samples will be hosted.

3. The Environmental Chamber

The Environmental chamber that will be used to carry out the experiment is a refurbishment of LISA-SAM that has originally been created by the Astronomy Department of University of Padua to study Martian atmosphere. The main structure of the machine is a steel cylinder inside which are located six cells with a 250 cm^3 capacity (see Figure 1).
Inside the cells can be placed biological samples like bacteria, yeasts or microorganisms. Cells are connected with the outer part by pipes at the end of which are implemented mechanical filters to let the gas to course and at the same time avoid biological material to go through the pipes inside the cryostatic chamber located under them.
Each cell must be kept at a temperature ranging from -25° C and 120° C, to simulate the most unfavourable thermal conditions that can be found on a terrestrial exoplanet.

References

[1] Rogers L.A., Seager S., 2010, Ap J, 716, 1208.