Solar and Stellar Variability: Impact on Earth and Planets
Proceedings IAU Symposium No. 264, 2009
A. G. Kosovichev, A. H. Andrei & J.-P. Rozelot, eds.

doi:10.1017/S1743921309993115

Exoplanet environments to harbour extremophile life

Eduardo Janot-Pacheco[1], Claudia A. S. Lage and Ivan G. P. Lima[3]

[1]Departamento de Astronomia, IAG, Universidade de São Paulo,
Rua do Matão 1226, 05508-090, São Paulo, Brazil
email: janot@astro.iag.usp.br

[2]Instituto de Biofisica Carlos Chagas Filho, Universidade Federal do Rio de Janeiro,
A. Carlos Chagas Filho, 373, 21941-902 Rio de Janeiro, Brazil
email: lage@biof.ufrj.br

[3]Instituto de Biofisica Carlos Chagas Filho, Universidade Federal do Rio de Janeiro,
A. Carlos Chagas Filho, 373, 21941-902 Rio de Janeiro, Brazil
email: igplima@biof.ufrj.br

Abstract. In this contribution, we estimate the temperature at the surface of known exoplanets and of their putative satellites for two albedo extreme cases (Venus and Mars) and present a selection of extremophiles living on Earth that can live under those conditions. We examine also the possibility of survival of microorganisms in planetary systems of variable stars.

Keywords. planets and satellites: general, astrobiology

1. Introduction

Extremophiles are micro-organisms that dwell in extreme conditions of either high or low temperature, high or low pH, variable salt concentration, complete dessication, toxic metals, toxic organic chemical compounds and high levels of pressure or radiation. Extremophiles are thus excellent candidates to exist under extraterrestrial conditions, even outside habitable zones (HZ), as in the moons of the solar system Titan and Europa.

2. Exoplanets

There are more than 370 exoplanets discovered up to know, mainly through the velocimetry method (Schneider 2009). Many giant, probably gaseous planets close to their central stars - dubbed "Hot Jupiters" - have been found, showing that there are planetary systems quite different from the solar system. The CoRoT and KEPLER satellites using the method of transits will increase the population of known exoplanets by one order of magnitude and make the sample less biased. The method of transits allows in particular the detection of small, rocky planets that are more suitable to harbour life.

3. Temperature estimates

The surface temperature estimation depends not only on the stellar temperature but also on the planet's albedo and atmospheric chemical composition which will define the extent of the greenhouse effect and on how the heat is distributed around the planet.

The present sample of known exoplanets is strongly biased: long period planets and less massive ones are more difficult to detect. Surface temperatures of the known exoplanets are thus on the average higher than for planets in an Habitable Zone.

Surface temperatures of a number of Neptune-like exoplanets have been estimated (e.g., Rivera *et al.* 2005; Bonfils *et al.* 2007; Demory *et al.* 2007). They are supposedly mainly composed of icy/rocky material, being formed without the extended gaseous atmosphere or having lost it. Some of them have orbital periods between 2 and 6 days and surface temperature ranges from 400 to 700 K.

Even in these particular cases, extremophiles existing on Earth (the so-called "hyper-thermophiles") could live in the coldests of them.

The most favourable case is the exoplanet Gliese 581c (Udry *et al.* 2007). It is a planet with about 5 Earth masses situated in the HZ of a MV star. In this case, for Earth-like or Venus-like albedos, the surface temperature of Gliese 581c is estimated to range between 270K and 313 K, respectively, a really conformable temperature for many extremophile existing on Earth.

One new, interesting alternative is to examine the temperature conditions in moons of gaseous giants in the HZ. We did this for seven gaseous giants in the HZ of their central stars. We give below the estimated surface temperatures at the surface of putative satellites of these exoplanets. HD 10697 (G5V; 6.35 M_J, 1072 d orbit) T$S \approx 264$ K HD37124 (G4V; 1.04 M_J, 155.7 d orbit) T$S \approx 327$ K HD134987 (G5V; 1.58 M_J, 260 d orbit) T$S \approx 315$ K HD177830 (K2IV; 1.22 M_J, 392 d orbit) T$S \approx 362$ K HD222582 (G3V; ?? M_J, 576 d orbit) T$S \approx 234$ K Again, extremophiles existing on Earth could live confortably under these temperatures.

Finally, we consider two more extreme cases: a) Exoplanet temperatures for extreme albedos: considering that the planets have albedos as that of Venus ($A \approx 0.7$) and Mars ($A \approx 0.2$). In a planet like the Earth, the surface temperature would then be in the range 230 K ¡ T_{Earth} ¡ 283 K; b) An exoplanet orbiting a variable star whose radiation flux may change by up to ≈ 300%. The planet surface temperature may vary by ≈ 30% which means that extremophiles can still live under these conditions.

4. Conclusions

We have shown that extremophiles known on Earth could survive many of the different environments present in exoplanets, regarding extremes of temperature (but also, of radiation, pressure, pH, salinity, water content, etc...). Extremophiles can also live on the surface of planets orbiting variable stars, whose average energy may vary by up to ≈ 300%. Besides the "classical" Habitable Zones, one should also consider *extremophile zones* in exoplanetary systems.

References

Bonfils, X. *et al.* 2007, *A&A* 474, 293
Demory, B. O. *et al.* 2007, *A&A* 475, 1125
Rivera, E. J. *et al.* 2005, *ApJ* 634, 625
Schneider, J. 2009, *http://exoplanet.eu*
Udry, S. 2007, *A&A* 469, 43