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Exploring planetary biomarkers: a new physical method coupled with new computational tool

Tommaso Grassi (1) and Eugenio Simoncini (2)

(1) Universitá di Roma - La Sapienza, Roma, Italy (tommasograssi@gmail.com), (2) CAB, INTA-CSIC, Madrid, Spain (eugenio.simoncini@gmail.com)

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Grassi, T.[1], Simoncini, E.[2]

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[1] *Department of Chemistry, Universitá di Roma "La Sapienza", P.le A. Moro, 5, 00185 Roma, Italy*
[2] *Centro de Astrobiología, INTA-CSIC, Ctra. de Torrejón a Ajalvir km 4, 28850 Torrejón de Ardoz, Madrid, España*

1 Abstract

It has long been observed that Earth's atmosphere is uniquely far from its thermochemical equilibrium state in terms of its chemical composition [?]. Studying this state of disequilibrium is important both for understanding the role that life plays in the Earth system, and for its potential role in the detection of life on other suitable planets.

We apply our newly developed methodology to calculate the extent of atmospheric chemical disequilibrium. This tool allows us to understand, on a thermodynamic basis, how life affected - and still affects - geochemical processes on Earth, and if other planetary atmospheres are habitable or have a disequilibrium similar to the Earth's one.

In order to achieve this purpose, we have developed a new formulation to account for the thermodynamic conditions of a wide range of planetary atmospheres, from terrestrial planets, and icy satellites to hot exoplanets [?, ?].

This work has been developed with the help of a new computational framework aimed at handling ODEs with ease and based on a robust and fast ODE solver. We present here this new programming tool that allows to build the necessary FORTRAN module containing the ODEs of any desired chemical set of reactions, including Jacobian and several optimization strategies.

In this work we compute the dissipation and generation rates of chemical free energy in the atmospheres of Earth and Mars and we present a first comparison of their thermodynamics disequilibrium. The proposed thermodynamic analysis of Earth's atmosphere is necessary for a future comparison with other planets' atmospheric disequilibrium. Our results have an impact in the definition of Habitable Zone.

References

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