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LIQUID WATER ON EXOMOONS OF FREE-FLOATING PLANETS

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A free-floating planet could host satellites, either after its ejection or captured at later stages. We present PATMO, a 1D model of the atmosphere of these hypothetical exomoons. Their atmospheric composition plays a key role in determining the surface temperature and, therefore, the presence of water on their surface. Using PATMO for atmospheric modeling, the chemical evolution in various layers was explored.

A Free-Floating planet (FFP) is a planetary-mass object orbiting the Galactic Center or around a non-stellar body, then a FFP is not irradiated by a star.

We use PATMO, a flexible code for modeling 1D planetary layered atmospheres that follow their chemical evolution. We limit ourselves to determine the occurence of liquid water on the surface of the exomoon (Kasting et al. 1993).

Opacity plays an important role in the thermal profile of an atmosphere. This can be simplified by using a mean averaged over all frequencies or gray opacity. Temperature can be expressed as

$$T(\tau)^4 = \frac{1}{2}T_{eff}^4(1 + D\tau), \qquad (1)$$

where D is the diffusivity factor, τ is the gray infrared optical depth (Marley and Robinson 2015). We compute the gray optical depth from tables of Rosseland mean opacities (Badescu 2010). The effective temperature depends on the energy budget. We assume tidal and radiogenic heating as an energy source.

We consider different surface pressures with their respective effective temperatures such that the surface temperature is maintained to 274.5 K, to allow liquid water. Different fluxes of cosmic rays were also explored. A summary of the cases explored can be found in Table 1. In Figure 1 we show the mass fraction of water in the atmosphere, as well as how it accumulates starting from the surface, noting that the first layers contain most of the water. The cases with stronger cosmic-rays flux evolve faster than the others, although, except for case 3, the final masses are comparable.

In the absence of stellar light, the chemistry is driven by cosmic rays and therefore depends on their attenuation through the atmosphere, which increases with pressure. The obtained temperature profiles effectively maintain liquid water, but play a marginal role in affecting chemical evolution in the lower atmosphere, where most of the mass of the atmosphere resides.

TABLE 1

PARAMETER SPACE EXPLORED IN THIS WORK

Case	p_0 [bar]	ζ [s^{-1}]	$T_{\rm eff}$ [K]
1	1	1.3×10^{-17}	163.9
2	1	10^{-12}	163.9
3	10	1.3×10^{-17}	97.3
4	10	10^{-12}	97.3

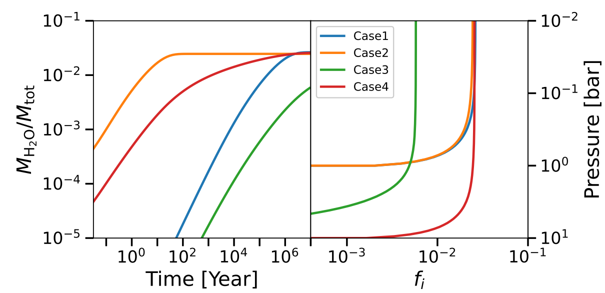

Fig. 1. Left: Total mass fraction of water over time. Right: Vertical distribution of the water mass fraction (cumulative across the layers) for the different cases.

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