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Influence of the radiation pressure on the planetary exospheres : analytical modeling of density profiles and escape flux

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The uppermost layer of the atmosphere, the exosphere, is not well-known in its global structure since the densities are very low compared to instrument detection capabilities. Because of rare collisions and high Knudsen numbers, the motion of light species (H, H2) in the corona is essentially determined by the external forces: the gravitation from the planet, the radiation pressure, etc...

In this work, we calculate rigorously and analytically, based on the Hamiltonian mechanics and Liouville theorem, the impact of the radiation pressure and gravitation from the planet on the structure of the exosphere. This approach was partially used by Bishop and Chamberlain (1989) but only in the 2D case: we extend it to the 3D case. Assuming a collisionless exosphere, we determine the density profiles for ballistic particles (the main contribution for densities in the lower exosphere) for light species as a function of the angle with respect to the Sun direction. We also obtain an analytical formula for the escape flux on the dayside at SZA=0°, which can be compared with the Jeans' escape flux. Finally, we show that the relative difference between the escaping flux with and without the radiation pressure depends linearly on the square root of the radiation pressure in first approximation.