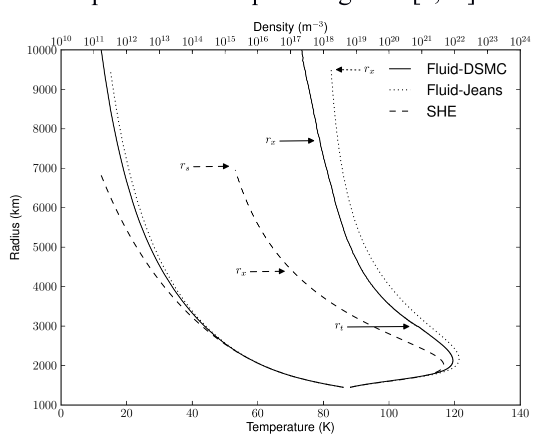
ATMOSPHERIC ESCAPE. J. T. Erwin, The Royal Belgian Institute for Space Aeronomy (BIRA-IASB), Ringlaan-3-Avenue Circulaire, B-1180 Brussels, Belgium (justin.erwin@aeronomie.be).

Introduction: All planetary bodies with an atmosphere experience some process of atmospheric escape, whether it is primarily due to thermal, diffusive, or non-thermal escape. These escape processes affect the density, temperature, and compositional structure of the upper atmosphere. In addition, in some circumstances, they can have importance in the lower atmosphere and the evolution of the entire atmosphere. This field of research remains active and continues to evolve as we explore our solar system and beyond.

Atmospheric Escape: Historically, atmospheric escape was thought to occur within two extremes: fast, supersonic expansion (via Parker's solar wind model) [1], and slow kinetic escape (via Jeans escape model). The former, with some modifications named Slow-Hydrodynamic Escape (SHE), was applied to many small bodies in the solar system as it was thought the low gravity would facilitate fast escape [2,3]. More recently, kinetic models of atmospheric escape have been used to properly model the transition between the collisional and collisionless regimes [4]. A systematic study showed that there exists a dynamic transition between the previous two extremes, with an enhanced Jeans-like region in between [5,6].

Therefore, recent models combine a fluid model with a kinetic upper boundary condition [7,8], or to combine a fluid and kinetic model to simulate the upper atmosphere and exosphere together [9,10].



In the above figure from [20], the 3 different escape models of Pluto's upper atmosphere result in different atmospheric structures. In particular, the SHE model is cooler and an atmosphere significant contracted compared to the kinetic models. However, the escape rates determined by these 3 models are very similar (due to conservation of energy). This case demonstrates that the atmospheric structure can be very sensitive to the escape mechanism (or alternatively the upper boundary condition).

A summary of these different escape models will be presented, along with a discussion of their respective implications. In addition, further concepts such as diffusion limited escape to the trace species, and energy limited escape will be put into context.

Pluto and New Horizons: Since the discovery of Pluto's atmosphere, significant effort has been made to understand it atmosphere. As a light body, the escape process was thought to be large and therefore dominant the upper atmospheric structure significant. Several models were applied and the prevalent theory evolved from SHE [2,11,12] to an enhanced Jeans Escape verified by kinetic models [19, 20]. Escape from the upper atmosphere, driven by UV absorption, drives adiabatic cooling to the mid and lower atmospheres. Hence it became necessarily to model the entire atmosphere together as many processes overlapped [13]. The result was a highly extended atmosphere, with a large but subsonic escape rate.

New Horizons found a very different atmosphere [14,15]. The upper atmosphere is much cooler and isothermal resulting with a slow escape rate. Some work has been made to explain this new picture of Pluto's atmospheric structure by including additional cooling agents (e.g. hydrocarbons and water) [16].

References:

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