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On the Mass-Radius Relation of Methane Planets

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Knowledge of both the mass and radius of an exoplanet allows us to estimate its mean density, and therefore, its composition. Exoplanets seem to fill a very large parameter space in terms of mass and composition, and unlike the solar-system's planets, exoplanets have intermediate masses ($\sim$ 5-50 $M_{\oplus}$) with various densities. We investigate the behavior of the Mass-Radius relation of methane (CH_4) planets and show that when methane planets are massive enough (the exact mass depends on dissociation pressure of methane) the methane can dissociate and lead to a differentiated planet with a carbon core, a methane envelope, and a hydrogen atmosphere. This leads to a kink in their Mass-Radius relation. The contribution of a rocky core to the behavior of CH_4 planets is considered as well. In addition, we develop interior models for several detected intermediate-mass planets that could, in principle, be methane-rich planets. The example of methane planets emphasizes the caution one must take when inferring the planetary composition from the Mass-Radius relation, and the importance of temperature and an accurate equation of state when modeling planetary interiors .