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Composition Effect on Mass-Radius Relation of Exoplanets

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In order to characterize the many hundreds of exoplanets that have been discovered, it is necessary to determine their internal structure and composition. For many exoplanets, masses and radii are available. The radius-mass relation can be substantially affected by the composition of the high-Z material, its mass fraction and its distribution within the planet. Adding high-Z material to a planet changes the density, energy and entropy profiles inside the planet, and contributes to the opacity as well. Therefore, in certain conditions the heat transfer and luminosity (and therefore contraction timescale) are also determined by the composition.
Here we model the evolution of giant and intermediate mass planets with various compositions and structures. We investigate the effects of the composition and its depth dependence on the long-term evolution of the planets. We study the influences of the heavy components, like rocks and ices, on the evolution of the planets by considering their contribution to the energy and also to the opacity. We calculate the EOS for a mixture of hydrogen and helium with heavy element for each of the planetary layers, and tie the grain opacity to the atmospheric metallicity in a self-consistent manner. The effect of stellar irradiation is also considered.
We find that the most important effect is that of the grain opacity due to the additional high-Z material in the envelope. This has the potential of increasing the computed radius of the planet by several tens of percent. The changes in radius due to various compositions and stellar irradiation also affect the planetary contraction but are found to be less important than the opacity effects. We suggest that the mass-radius relationship used for characterization of observed exoplanets should be taken with great caution since different physical conditions can result in very different mass-radius relationships.
Moreover, assuming constant composition distribution inside the planet in time is not necessarily correct. We calculate mass redistribution processes, like core erosion by convection, during the planetary evolution, for different initial assumptions. We show effects of mass redistribution on the inner structure and mass-radius relationship of exoplanets.