Thermal evolution and interior models of the transiting super-Earth GJ 1214b

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The planet GJ 1214b is the second known super-Earth with a measured mass and radius. Orbiting a quiet M-star, it receives considerably less mass-loss driving X-ray and UV radiation than CoRoT-7b, so that the interior may be quite dissimilar in composition, including the possibility of a large fraction of water. We model the interior of GJ 1214b assuming a two-layer (envelope+rock core) structure where the envelope material is either H/He, pure water, or a mixture of H/He and H2O. Within this framework we perform models of the thermal evolution and contraction of the planet. We discuss possible compositions that are consistent with Mp=6.55 ME, Rp=2.678 RE, an age tau=3-10 Gyr, and the irradiation level of the atmosphere. These conditions require that if water exists in the interior, it must remain in a fluid state, with important consequences for magnetic field generation. These conditions also require the atmosphere to have a deep isothermal region extending down to 80-800 bar, depending on composition. Our results bolster the suggestion of a metal-enriched H/He atmosphere for the planet, as we find water-world models that lack an H/He atmosphere to require an implausibly large water-to-rock ratio of more than 6:1. We instead favor a H/He/H2O envelope with high water mass fraction (~0.5-0.85), similar to recent models of the deep envelope of Uranus and Neptune. Even with these high water mass fractions in the H/He envelope, generally the bulk composition of the planet can have subsolar water:rock ratios. Dry, water-enriched, and pure water envelope models differ to an observationally significant level in their tidal Love numbers k2 of respectively ~0.018, 0.15, and 0.7.

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