EPSC Abstracts
Vol. 13, EPSC-DPS2019-1728-1, 2019
EPSC-DPS Joint Meeting 2019

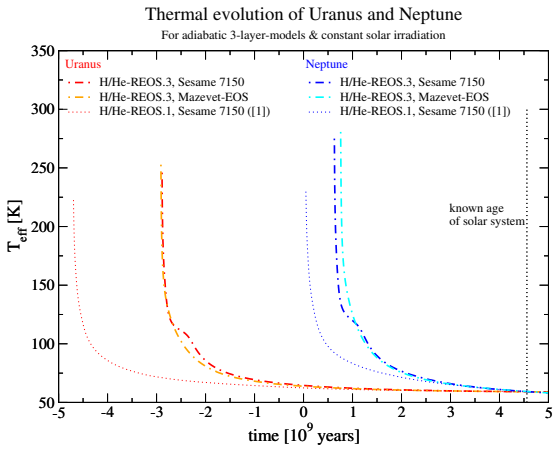
EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

Thermal evolution of Uranus and Neptune

Ludwig Scheibe, Nadine Nettelman and Ronald Redmer
Institute for Physics, University of Rostock, Germany

Abstract

Uranus and Neptune have highly different intrinsic heat fluxes. This is surprising since they share a large number of very similar observed values such as mean density, surface temperature and atmospheric composition. Moreover, previous evolution calculations fail to reproduce the present-day luminosity of Uranus, or – equivalently – yield too long cooling times [1, 5].
Here we investigate how different equations of state for H/He and for water affect the luminosity of assumed adiabatic models. We find that application of H/He-REOS.3 [3] yiels $\sim$ 0.6 Gyr (Neptune) and $\sim$ 1.8 Gyr (Uranus) shorter cooling times for the ice giants compared to the previously used H/H-REOS.1 [2] and Sesame 7150 EOS [4]. This trend is confirmed if we apply the recent EOS by Mazevet *et al* for water [6]. As a result, adiabatic Neptune appears too bright for its known age (see figure).
Finally, we also present work in progress on non-adiabatic models. For that purpose we have developed a new tool based on the well-known Henyey method for stellar structure and evolution calculations [7].



Acknowledgements

This project was funded by the DFG grant NN1734/2 within the DFG research unit FOR 2440 “Matter Under Planetary Interior Conditions”.

References

[1] Fortney, J. J., Ikoma, M., Nettelmann, N., Guillot, T., and Marley, M.S.: Self-consistent model atmospheres and the cooling of the solar system’s giant planets. Planet. ApJ, Vol. 729, p. 32, 2011.

[2] Nettelmann, N., Holst, B., Kietzmann, A., French, M., Redmer, R., and Blaschke, D.: Ab initio equation of state data for Hydrogen, Helium, and water and the internal structure of Jupiter. ApJ, Vol. 683, pp. 1217-1228, 2008.

[3] Becker, A., Lorenzen, W., Fortney, J. J., and Nettelmann, N.: Ab initio equations of state for Hydrogen (H-REOS.3) and Helium (He-REOS.3) and their implications for the interior of brown dwarfs. ApJS, Vol. 215, pp. 21–35, 2014.

[4] Lyon, S. P., and Johnson, J. D.: SESAME: The Los Alamos National Laboratory equation of state database (LA-UR-92-3407). Los Alamos National Laboratory, LANL report no. LA-UR-92-3407, 1992.

[5] Nettelmann, N., Helled, R., Fortney, J. J., and Redmer, R.: New indication for a dichotomy in the interior structure of Uranus and Neptune from the application of modified shape and rotation data. Planet. Space Sci., Vol. 77, pp. 143-151, 2013.

[6] Mazevet, S., Licari, A., Chabrier, G., and Potekhin, A. Y.: Ab initio based equation of state of dense water for planetary and exoplanetary modeling. A&A. Vol. 621, p. A128, 2019

[7] Henyey, L.G., Forbes, J.E., and Gould, N.L.: A New Method of Automatic Computation of Stellar Evolution. ApJ, Vol. 139, pp. 306-317, 1964.