EPSC Abstracts
Vol. 7 EPSC2012-759 2012
European Planetary Science Congress 2012

Atmospheric Gravitational Tides on Close-In Extrasolar Giant Planets

Chris Watkins and James Y-K. Cho.
School of Physics and Astronomy, Queen Mary University of London, UK (c.watkins@qmul.ac.uk, J.Cho@qmul.ac.uk)

Abstract

Currently, all models of extrasolar planet circulation are initialized with either a turbulent atmosphere or an atmosphere at rest (e.g., [2,4,6]). Recently, it has been shown that the output of such models is dependent on the initial conditions used [5]. Therefore, it is important to understand what types of physically plausible initial flow states are possible for extrasolar planets.

Understanding the circulation maintained by gravitational and thermal tides can help constrain the possible circulation patterns that can be used in model initializations. Here, we focus on gravitational tides and present results from a study of those tides raised on asynchronous close-in extrasolar giant planets by the host star. These tides, which continue to be raised until the planet becomes putatively synchronized, strongly determine the circulation until that point through wave-mean flow interaction and saturation. Thus, they provide insight into possible initial condition for atmospheric flow models of synchronized planets.

Classical tidal theory (e.g., [1]) has been successfully applied for the Earth. However, the theory cannot be used without modification for giant planets [3]. Further modifications are required for applications to close-in extrasolar planets because of the much greater atmospheric flow speeds suggested by current circulation modeling studies. In this work, we extend the classical theory of atmospheric tides to include, among others, background mean flow and deep atmospheres. A full, three-dimensional general circulation model is used in this work.

References

[1] Chapman, S., and Lindzen, R.: Atmospheric Tides: Thermal and Gravitational, D. Reidel Publishing Company, 1970.

[2] Heng, K., Menou, K., and Phillipps, P.: Atmospheric Circulation of Tidally Locked Exoplanets: A Suite of Benchmark Tests for Dynamical Solvers, Mon. Not. R. Astron. Soc., Vol. 413, pp. 2380-2402, 2011.

[3] Ioannou, P., and Lindzen, R.: Gravitational Tides on Jupiter. III. Atmospheric Response and Mean Flow Acceleration, Astrophys J, Vol. 424, pp. 1005-1013, 1994.

[4] Menou, K., and Rauscher, E.: Atmospheric Circulation of Hot Jupiters: A Shallow Three Dimensional Model, Astrophys. J., Vol. 700, pp. 887-897, 2009.

[5] Thrastarson, H., and Cho, J. Y-K.: Effects of Initial Flow on Close-In Planet Atmospheric Circulation, Astrophys J, Vol. 716, pp. 144-153, 2010.

[6] Thrastarson, H., and Cho, J. Y-K.: Relaxation Time and Dissipation Interaction in Hot Planet Atmospheric Flow Simulations, Astrophys. J., Vol. 729, pp. 117-127, 2011.