Geophysical Research Abstracts
Vol. 17, EGU2015-6237, 2015
EGU General Assembly 2015

Incorporation of Helium Demixing in Interior Structure Models of Saturn

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Experiments and *ab initio* calculations of hydrogen-helium mixtures predict a phase separation at pressure-temperature conditions relevant to Saturn's interior. At depths where this occurs, droplets of helium form out of the mixture and sink towards the deep interiors where it re-mixes again, thereby depleting the helium above the layer over time while enriching the concentration below the layer. In dynamo modelling, the axisymmetric nature of Saturn's magnetic field is so far best explained by the inclusion of a stably stratified layer just below the depth at which hydrogen metallizes (approximately $0.65R_S$). Stable stratification at that depth could occur if the compositional gradients produced by the helium rain process described above is great enough to suppress convection in the de-mixing layers.

Thus, we first developed a range of interior structure models consistent with available constraints of the gravity field and atmospheric composition. The hydrogen-helium de-mixing curve was then incorporated in calculations of some of these models to assess its feasibility in compositionally stratifying the top of the dynamo source region.

We found that when helium rain is taken into account, a stably stratified layer approximately $0.1 - 0.15R_S$ in thickness can exist atop the dynamo source region, consistent with thicknesses needed in dynamo models to axisymmetrize the observable magnetic field. Furthermore, inertial gravity waves could be excited in such thick stably stratified regions. These may be detectable by asteroseismology techniques, or by analysis of wave modes' gravitational interaction with Saturn's ring particles. Thus, profiles of sound speed and Brunt-Vaisala frequencies were also calculated for all of the interior structures models studied to be used for comparison with possible seismic studies in the future.