Understanding of Saturn's North Pole Hexagon

MASTER THESIS

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Abstract

A hexagonal pole-centered atmospheric feature in the northern hemisphere of Saturn was first observed by the Voyager flybys in 1981. Continuous observations showed it to have persisted throughout seasonal changes, i.e. external forcing mechanisms are not mandatory [Godfrey, 1988; Sánchez-Lavega et al., 2014]. Efforts to explain its characteristics indicate that barotropic instability plays an important function [Aguiar et al., 2010; Morales-Juberías et al., 2011; Sánchez-Lavega et al., 2014; Morales-Juberías et al., 2015].

We outline the dynamics of Saturn's atmospheric circulation and successfully set up a numerical model to conduct a thorough parameter study. Because of insufficient information on the interior of Saturn's vertical structure, our first approach is a single-layered reduced gravity model. A domain of parameters: channel width, initial zonal velocity, initial jet width, and dissipation are efficiently tested without the need to speculate unknown variables. Parameter sensitivity is diagnosed through rms and mean averages for zonal velocity and surface height.

Finding an analogy for real viscosity values on Saturn proved to be complicated, thus it can only be stated that the role of dissipation must be low enough for the jet to undulate and to form vortices, otherwise it remains as a straight jet before fading. Initial jet width and u-velocity are identified to be most influential, in favorance of narrow and high-velocity jet streams. A zonal jet is likely to become unstable when its latitudinal position is within a certain zone: sufficiently distant from the Equator as to not elicit strong and flattening Coriolis force effects, but reasonably close to the polar vortex for energy balance benefits. The mentioned conditions are ubiquitous to gas-giant planets, possibly indicating more commonality in the existence of polygonal features than previously thought.