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A Greens-function solution linking gravity measurement to the zonal winds in gas planets

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The unprecedented precisions of Juno gravity measurements at Jupiter and Cassini gravity measurements at Saturn allows constraining the depth of the zonal winds on both planet. The link between gravity and winds can be derived based on the azimuthal component of the vorticity equation. This yields a diagnostic equation that relates the dynamic density disturbance to a matching zonal wind gradient in the direction of the rotation axis. It is an open question whether self-gravity effects are important in the diagnostic equation or could be neglected (thermal-gravitational wind vs. thermal wind approach). Here we demonstrate that the dynamic gravity potential disturbance (roughly) obeys a Helmholtz equation that smoothly transitions to the classical Poisson equation when the self-gravity effects become negligible. A Greens-function solution, using spherical Bessel functions as radial basis function, allows addressing the impact of the self-gravity. We show that the respective effects become negligible for spherical harmonic degrees beyond five and show first illustrative solutions for Jupiter and Saturn.