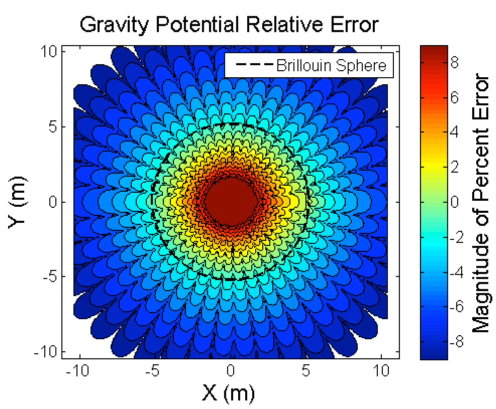
Characterization of the exterior spherical harmonic gravity potential divergence

Kiichiro J. DeLuca [1] and Daniel J. Scheeres [1]

[1] *Department of Aerospace Engineering Sciences, University of Colorado Boulder, Boulder, CO 80309*
kiichiro.deluca@colorado.edu

Abstract. Navigation systems on future small body missions will require accurate models of the highly perturbed dynamical environment to deliver sufficient accuracy in the state estimates for close proximity operations. For small bodies, one of the driving perturbations is the non-spherical gravity field. The classical spherical harmonic expansion, also known as the exterior gravity field, has historically been the method of choice to model perturbed gravity fields. However, the exterior gravity field is known to diverge within the Brillouin sphere, which is the sphere that circumscribes all mass elements of the body. Takahashi, Scheeres, and Werner [1] showed that an alternative spherical harmonic expansion, the interior gravity field as explained by Werner [2], could be combined with the exterior gravity field to create common convergence regions all the way down to the surface of a small body. Their results characterized the benefit of this novel method for localized regions and along specific trajectories, but not globally. Our results first show that the actual divergence boundary of the exterior gravity field falls within the Brillouin sphere for a non-spherical mass distribution. Furthermore, we characterize the degree to which the combination of the exterior and interior gravity fields globally mitigates the divergence of the exterior gravity field. Finally, based on these numerical results, we introduce a method for approximating the divergence characteristic of the exterior gravity field for an arbitrary body, without any knowledge of the true gravity field. The results of this study can help future small body missions determine appropriate representation of the gravity field for specific mission requirements.



[1] Takahashi, Y., Scheeres D. J., and Werner R. A., "Surface Gravity Fields for Asteroids and Comets," Journal of Guidance, Control, and Dynamics 36 (2013): 362-374.
[2] Werner, R.A., "Evaluating Descent and Ascent Trajectories Near Non-Spherical Bodies," Technical Report, NASA Tech Briefs, 2010. NPO-46697.