MASS ANOMALIES ON GANYMEDE. G. Schubert, *Department of Earth and Space Sciences, Institute of Geophysics and Planetary Physics, University of California, Los Angeles CA 90095–1567, USA, (schubert@ucla.edu)*, J. D. Anderson, R. A. Jacobson, E. L. Lau, *Jet Propulsion Laboratory, California Institute of Technology Pasadena CA 91109–8099, USA*, W. B. Moore, J. Palguta, *Department of Earth and Space Sciences, University of California, Los Angeles*.

Radio Doppler data from two Ganymede encounters (G1 and G2) on the first two orbits in the Galileo mission have been analyzed previously for gravity information [1]. For a satellite in hydrostatic equilibrium, its gravitational field can be modeled adequately by a truncated spherical harmonic series of degree two. However, a fourth degree field is required in order to fit the second Galileo flyby (G2). This need for a higher degree field strongly suggests that Ganymede's gravitational field is perturbed by a gravity anomaly near the G2 closest approach point (79.29° latitude, 123.68° west longitude). In fact, a plot of the Doppler residuals (Figure 1), after removal of the best-fit model for the zero degree term (GM) and the second degree moments (J_2 and C_{22}), suggests that if an anomaly exists, it is located downtrack of the closest approach point, closer to the equator.

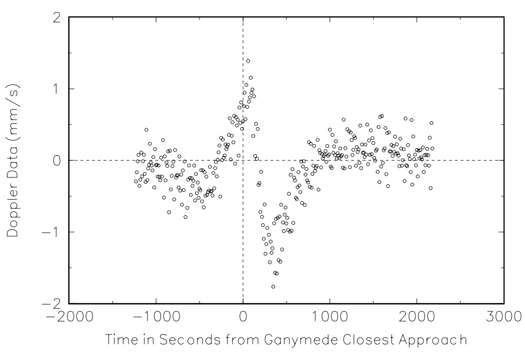

Figure 1: Doppler residuals for the G2 flyby, after removal of a model that includes the best-fit mass GM and second degree moments J_2 and C_{22}. Since there is a gap in the data just before the first data point, it is impossible to continue the plot to an earlier time when the anomaly has completely disappeared from the Doppler data.

An anomalous acceleration projected along the line of sight (LOS) can be obtained by numerically differentiating the Doppler residuals of Figure 1 with respect to time. This differentiation is performed by fitting the Doppler residuals with a sequence of cubic splines that also yield the first derivatives. This is the standard method for studying gravity anomalies. It was used for the discovery of lunar mascons in the 1960s.

A good fit to the LOS accelerations of Figure 2 can be obtained by modeling the G2 anomaly by a number of mass points. In fact a good fit can be obtained with just two mass points. One mass is negative and is located on Ganymede's surface at a radius of 2631.2 km near the closest approach point. The other mass is positive and is located nearer the equator at Ganymede's rock-ice boundary, defined here by a radius of 1831.2 km (800 km depth). However, these locations are at odds with the theory of isostatic compensation, which should be applicable to Ganymede. For that reason, a more physical model is used. It consists of pairs of mass points at the same latitude and longitude. The first mass of the pair is at a radius of 1831.2 km, and the second mass is assumed the negative of the first at a radius of 2631.2 km. Two such mass pairs yield an excellent fit to the acceleration data. However one of the pairs is unstable against variations in the acceleration data. Therefore, we reject this unstable pair, and instead accept a less than ideal fit with just one mass pair. Since it is unlikely that mass points are the correct model for the G2 gravity anomaly, a less than ideal fit is justified. Presumably a better fit could be achieved by fitting with extended mass distributions, not mass points. The least-squares fit to the acceleration data is shown in Figure 2.

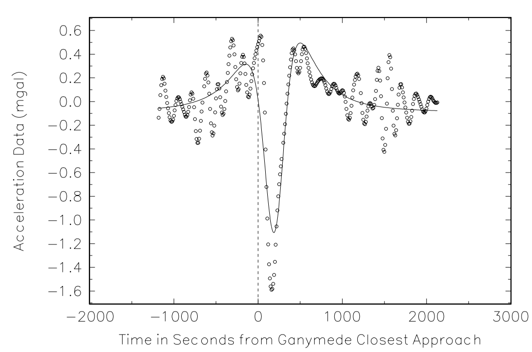

Figure 2: LOS accelerations (mgal) obtained by the cubic-spline technique applied to the Doppler residuals of Figure 1. The solid line represents the best-fit gravity anomaly modeled by the single isostatically compensated mass pair of Eq. 1.

The location and magnitude of the single mass pair is,

$$\begin{aligned} \text{Mass} &= (6.60 \pm 0.61) \times 10^{18}\ \text{kg} \\ \text{Latitude} &= (19.41 \pm 0.78)\ \text{Degrees} \\ \text{West Longitude} &= (54.59 \pm 2.07)\ \text{Degrees} \qquad (1) \end{aligned}$$

where the mass is given for the mass point at a radius of 1831.2 km, the assumed rock/ice boundary. The surface mass point at the radius of 2631.2 km has a mass equal to the negative of the mass in Eq. 1, and is at the same latitude and longitude.

Although the fitting model of a single mass pair produces a less than ideal fit, it is not bad. In fact, it is representative of a smoothing of the accelerations, with the dip in the fitting curve a smoothed version of the dip in the acceleration data.

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Reference: [1] (Anderson et al. (1996) *Nature*, *384*, 541–543.