INTERIOR MODELS OF IO AND THE SURFACE DISTRIBUTION OF HOT SPOTS. M. Segatz and T. Spohn, Institut für Planetologie, Westfälische Wilhelms-Universität, Corrensstraße 24, D-4400 Münster

The distribution of hot spots on Io's surface constrains models of Io's interior. Voyager observations indicate that most hot spots and volcanic plumes are located close to the equator. It has recently been proposed, however, that a large low albedo feature in the south polar region may be the source of 40% of the surface heat flow (McEwen et al., 1985). We calculate the spatial distribution of the dissipation rate and an apparent surface heat flow for a three layer and a four layer Maxwell-rheology model of Io. The models consist of an inviscid Fe-FeS core, a viscoelastic silicate mantle and an elastic silicate lithosphere. In addition, the four layer model has a partially molten asthenosphere of a few tens of kilometers thickness.

The deformation of Io due to the radial and librational tidal disturbance potential is calculated by using the correspondence principle. The total tidal dissipation rate E_T is determined from the imaginary part of the secondary Love-number k_2.

$$E_T = \frac{21}{2} \frac{(nR)^5 e^2}{G} \cdot \mathrm{Im}(k_2)$$

n is the mean motion, R the satellite's mean radius, e the orbit eccentricity, and G is the gravitational constant. This equation is valid for any complex model of a satellite and is a generalization of the equation for a homogeneous satellite given by Peale et al. (1979).

In case of a three layer model with a mantle shear modulus of $6 \cdot 10^{10}$ Pa, a viscosity of $4 \cdot 10^{16}$ Pa·s is required to balance tidal dissipation in the mantle and the observed heat loss of $(6 \pm 2) \cdot 10^{13}$ W. As compared with a homogeneous model,

the presence of the core doubles the dissipation rate while the elastic lithosphere has only a minor effect of less then 5%. Tidal dissipation is largest along the polar axis and increases from the lithosphere towards the core. Integration of the heat source density over radial distance gives an apparent surface heat flow which has maxima at the poles and minima at the sub-Jovian and anti-Jovian points. With the north polar heat flux unconstrained by observation, a strong south polar hot spot is in favour of the three layer model. On the contrary, dissipation in a molten or partially molten asthenosphere has maxima along the equator and is the favoured model if strong polar hot spots cannot be confirmed by observation. An asthenosphere of 10^9 Pa·s is required to balance the Ionian surface heat flow by tidal dissipation in a 75 km thick asthenosphere. Because the dissipation rate decreases with viscosity and with increasing asthenosphere thickness, a runaway thickening of the asthenosphere is prevented. Therefore, the oscillatory thermal and orbital evolution scenario proposed by Greenberg (1982) is unlikely if dissipation occurs mainly in the asthenosphere. A lithosphere thickness of about 25 km maximizes the dissipation rate in the asthenosphere and is compatible with the observed topography.

References:

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