ENCELADUS: INTERNAL DYNAMICS AND HEAT PRODUCTION BY TIDAL FRICTION. Hauke Hussmann, Matthias Grott and Frank Sohl, DLR Institute of Planetary Research, Rutherfordstr. 2, 12489 Berlin, Germany (e-mail: hhussman@uni-muenster.de)

Introduction: Tidal friction can be a major heat source of outer planet satellites. Io and Europa are prominent examples for which tidal heating plays a major role (Io) [1] or contributes significantly to the overall energy budget (Europa) [2]. The Cassini spacecraft has detected ongoing geologic activity near the south pole of Saturn's moon Enceladus [3,4]. In contrast, its north-polar region is heavily cratered and appears to have been geologically inactive for a long time. Such a strong focus of internal heating and activity towards the south pole of Enceladus is a major difference compared to Io and Europa. We propose that this hemispheric dichotomy is caused by the satellite's interior dynamics and that a degree-one convection pattern is driving the south-polar activity [5]. The required internal heating rate is in the range of the estimated heat production of several GW [4] in Enceladus. We investigate under which conditions such heating rates can be provided by tidal friction.

The Model: Thermal convection in Enceladus is studied by modeling the satellite as an icompressible viscous fluid undergoing creeping flow. The equations of mass, momentum, and energy conservation are solved numerically using appropriate mechanical and thermal boundary conditions at the surface and core mantle boundary. The core size and the internal heating rate are varied to search for solutions in which a one-degree pattern develops. The core sizes represent different degrees of differentiation.

As a first approach we calculate the amount of heating due to inelastic tidal deformation for similar structure models independently from the convection model. Inelastic deformation is determined by the imaginary parts of the tidal Love numbers h_2, k_2, and l_2. The heating rate for a synchronously rotating satellite is proportional to the imaginary part of k_2 [1]. For the present orbital state we calculate the heating rates for models with and without internal liquid layers. Tidal amplitudes are deduced from h_2 for the various models.

Results and Conclusions: We investigated a number of core sizes and internal heating rates for which degree-one convection occurs. Best conditions for degree-one convection to develop are small cores, large heating rates and a decoupling between core and mantle, i.e. a free-slip boundary condition. The numerical simulations imply that a core radius of less than 120 km and an energy input at a rate of 3.0 to 5.5 GW would be required for degree-one convection to prevail. This is within the range of the observed thermal power near Enceladus' south pole [4]. Provided that Enceladus is not fully differentiated, degree-one convection is found to be a viable mechanism to explain Enceladus' hemispheric dichotomy. The models presented do require an incomplete differentiation of Enceladus, which may be inferred from dedicated flybys during Cassini's extended mission. In case of full differentiation, a core size of about 160 km is expected based on the mean density of the satellite. Such a large core would imply a thin convecting layer on top which would not allow for large scale structures to prevail.

Heating rates due to tidal friction would in principle be sufficient to power the observed activity on Enceladus. However, this will require a decoupling of the outer ice shell from the deep interior. Without a decoupling layer the heating rates would be about an order of magnitude too small to be consistent with Enceladus' output of energy. It is difficult to explain the focusing of activity towards the south-pole within the framework of tidal deformation, which would be symmetric, provided that the internal structure is symmetric. One-degree convection, which can develop even if the heat sources are distributed homogeneously may be one possibility to concentrate tidal heating in one hemisphere. The tidal Love numbers, *h*, *k* and *l* describe a satellite's response to the external periodic forcing and do strongly depend on the satellite's internal structure, chemical composition, thermal state, and frequency of the forcing. These global parameters (or linear combinations of the latter) can be deduced from line-of-sight gravity field measurements acquired during close flybys, from orbiting spacecraft, and from measurements at the satellites' surfaces. To confirm (or rule out) the presence of a global liquid layer at Enceladus, different flyby geometries would be extremely useful. Deducing the degree of internal differentiation of Enceladus would be important to further constrain the models presented.

References: [1] Segatz et al. (1988) *Icarus, 75*, 187 – 206. [2] Hussmann et al. (2002) *Icarus, 156*, 143 – 151. [3] Porco, C.C. et al. (2006) *Science, 311*, 1393–1401. [4] Spencer, J.R. et al. (2006) *Science., 311*, 1401 - 1405. [5] Grott, M. et al. (2007) *Icarus, in press*.