Obliquity tides have an impact in diurnal tidal stresses on the Moon.

M. Wüsthoff[1,2] (martin.wuesthoff@dlr.de) and F. Sohl[2] (frank.sohl@dlr.de), [1]Institute of Physics and Astronomy, University Potsdam, [2]Institute of Planetary Research, German Aerospace Centre (DLR).

Introduction: We examine possible consequences of the significant tilt of about 6.7° of the lunar spin axis relative to the pole of the orbital plane for diurnal tidal stresses on the Moon. For example, even small obliquities of less than 0.5° could substantially influence the characteristic pattern of diurnal tidal stresses, as recently demonstrated for the Jovian icy satellite Europa [1]. Though the tidal environments and tidally effective rigidities of the Moon and Europa differ from each other, the lunar spin axis tilt is more than one order of magnitude larger than Europa's obliquity, thereby substantially affecting the diurnal variation of tide-induced global surface stress pattern on the Moon.

Model: The modelling of stresses due to eccentricity tides as outlined in Wahr et al. (2009) [2] is expanded with respect to non-zero obliquity. The extended tidal potential possesses an additional obliquity term and is based on the work by Jara-Orué and Vermeersen (2011) [1]. For the calculation of the time-variable global surface stress pattern, the Python package satstress [3] was used. Density models of the lunar interior are based on inferred values of the mean density, mean moment-of-inertia factor and crustal density of the Moon [4,5]. The reference model used in the present study is subdivided into a small solid inner core, a fluid outer core, and a solid silicate mantle overlain by a crust layer.

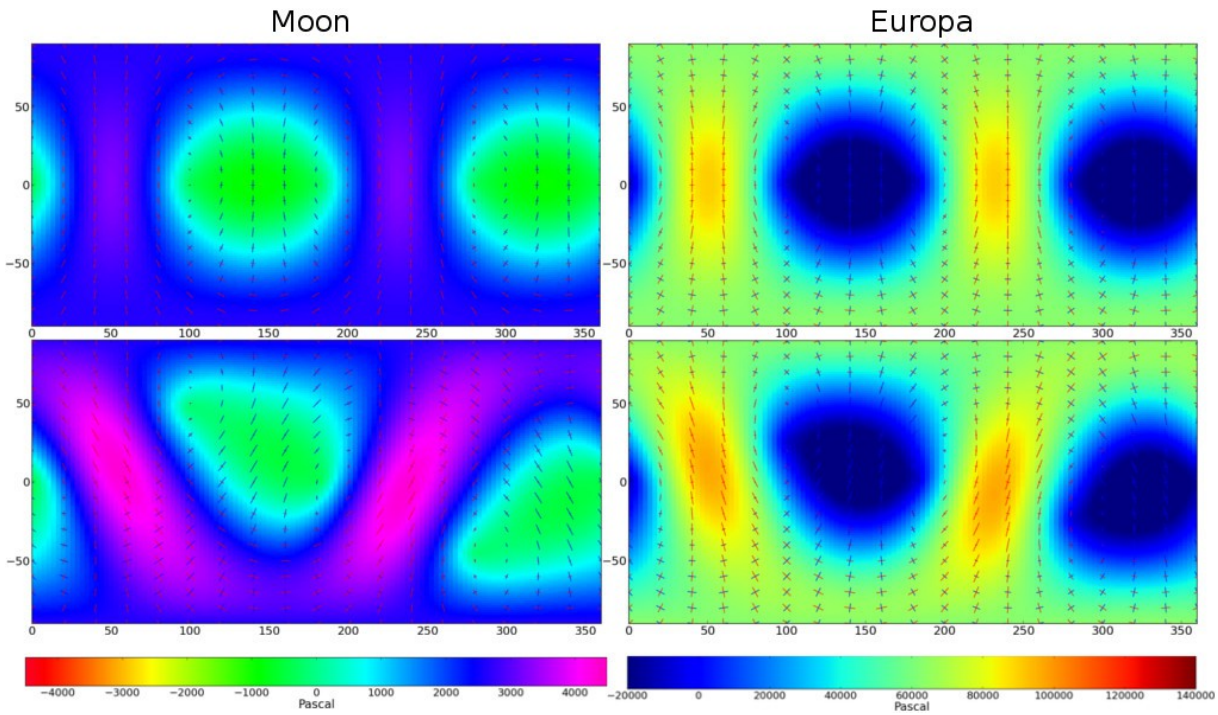

Figure 1: Global stress fields of the Moon (left) and of the Jovian satellite Europa (right) at orbital longitude 100° caused by eccentricity tides alone (top) and eccentricity plus obliquity tides (bottom) respectively.

Results: As seen in figure 1, the global surface stress field would change from symmetrical to asymmetrical if the tilt of the spin axis is accounted for. Because of the asymmetrical character of the tide-induced surface stresses, the global stress maxima will follow sinusoidal pathways from perigee to apogee, thereby reaching higher latitudes compared to pure eccentricity tides. Furthermore, the maximum stress values of compression and tension are larger when the spin axis tilt is taken into account (lunar case: 30% larger stress values) and the relatively changes of maximum stress values are more significant in the lunar case .

References: [1] Jara-Orué H. M. and Vermeersen B. L. A. (2011) Icarus, 215, 417-438. [2] Wahr J. et al. (2009) Icarus, 200, 188-206. [3] Selvans Z.A.: Package satstress, released under GNU General Public License V.3, http://code.google.com/p/satstress. [4] Harada Y. et. al. (2014), Nature Geoscience, 7, 569-572. [5] Wieczorek M. A. et al. (2013), Science, 339, 671-675.