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Matrix Pseudospectral Method for (Visco)Elastic Tides Modeling of Planetary Bodies

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We deal with the equations and boundary conditions describing deformation and gravitational potential of prestressed spherically symmetric elastic bodies by decomposing governing equations into a series of boundary value problems (BVP) for ordinary differential equations (ODE) of the second order. In contrast to traditional Runge-Kutta integration techniques, highly accurate pseudospectral schemes are employed to directly discretize the BVP on Chebyshev grids and a set of linear algebraic equations with an almost block diagonal matrix is derived. As a consequence of keeping the governing ODEs of the second order instead of the usual first-order equations, the resulting algebraic system is half-sized but derivatives of the model parameters are required. Moreover, they can be easily evaluated for models, where structural parametres are piecewise polynomially dependent. Both accuracy and efficiency of the method are tested by evaluating the tidal Love numbers for the Earth's model PREM. Finally, we also derive complex Love numbers for models with the Maxwell viscoelastic rheology, where viscosity is a depth-dependent function.

The method is applied to evaluation of the tidal Love numbers for models of Mars and Venus. The Love numbers of the two Martian models - the former optimized to cosmochemical data and the latter to the moment of inertia (Sohl and Spohn, 1997) - are h2=0.172 (0.212) and k2=0.093 (0.113). For Venus, the value of k2=0.295 (Konopliv and Yoder, 1996), obtained from the gravity-field analysis, is consistent with the results for our model with the liquid-core radius of 3110 km (Zábranová et al., 2009). Together with rapid evaluation of free oscillation periods by an analogous method, this combined matrix approach could by employed as an efficient numerical tool in structural studies of planetary bodies.

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