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Multi-Component Decomposition of Elastic Velocities in Cometary Materials as Measured by the CASSE Experiment

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The CASSE experiment aboard the Rosetta lander Philae will record artificial and natural vibrations of the cometary surface. One of the scientific goals is to determine elastic properties like shear and compressional wave velocities, bulk modulus, shear modulus, and Poisson ratio. The spatial variations of these parameters, especially with depth, will also be investigated.

Determination of the elastic constants is not simply an end in itself but can lead to estimations of compositional parameters of cometary material. An unambiguous inversion in terms of materials, however, is not feasible since the intervals of possible elastic velocities for different compositions overlap. We present a non-linear Monte Carlo approach to decompose the elastic wave velocities into compositions of likely substances, expressed as volume fractions. The inversion is based on mixing theories for bulk and shear modulus and a dedicated library of matter properties. The number of constituents considered in the inversion is not limited by the method, although a larger number of constituents will result in a larger uncertainty of the resulting volume fractions. The inversion will thus benefit much from results of chemical and spectroscopic analyses.

For each candidate mixture generated by the Monte Carlo process and represented by the respective volume fractions, elastic moduli and hence velocities are computed. As misfit measure, a weighted mean of the differences between the computed and observed velocities, expressed in units of the measurement standard deviation, is implemented. All compositions that comply with the measurement within two standard deviations (95% level for normal distributions) should be considered as possible (non-falsification).