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A scheme of integrals of motion for gravity field determination based on precisely observed low Earth satellites

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In the area of gravity field recovery using satellite orbits, the missions CHAMP and GRACE suggest a paradigm shift in the mathematical modelling concepts. Owing to the availability of orbits tracked continuously with high accuracy, the classical approaches based on the theory of accumulated orbit perturbations can be replaced by those which uncover the gravity signals in-situ by connecting the orbit immediately with Newton's equation of motion. This new class of analysis techniques is divided naturally in three subclasses depending on the number of differentiations which have to be performed to connect the satellite's positions with the unknown forces. In this scheme the central position is occupied by the so-called first integrals of motion in which besides the position vectors only the satellite's velocities occur. A close look reveals that ten integrals with this property exist, four of them being scalars, such as the satellite's total energy, the others vector-valued, e.g. the balance equations of the linear momentum and the angular momentum and the energy balance in the coordinates. Selected examples based on real kinematic orbits of CHAMP demonstrate the usefulness of different integrals of motion for gravity field determination tasks - but also their typical characteristics.