Implications of dynamical stability for the detection of Super-Earths via transit timing variation method

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Measurement of variations in the transit timing of a close-in giant planet is an efficient way to detect small bodies in transiting systems. Known as Transit Timing Variation method, TTV is particularly efficient in detecting small planets in mean-motion resonant (MMR) orbits. We have carried out an extensive search of the parameter-space for identifying stable MMRs between a transiting giant planet and a Super-Earth object that will produce high TTV signals. We have studied the effects of interior and exterior MMRs on the detectability of Super-Earths, and have shown that for a tidally locked Jovian body, a Super-Earth companion has a greater chance of detection if it has a long-term stable orbit with low eccentricity and low inclination, and in a low-order MMR. Our simulations also indicate that regions may exist in the vicinity of unstable MMRs, where a Super-Earth object can maintain its orbit for a long time and produce strong TTV signals. We present the results of our study, and discuss the capability of TTV method in detecting Super-Earth objects in more detail.

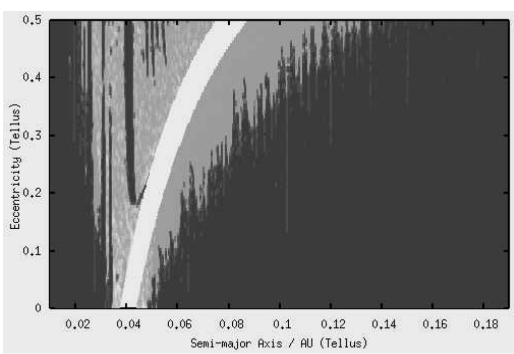

Figure 1: Graph of *(e-a)* space for a Super-Earth (15M_E) in a transiting system with a 3-day orbit giant planet. Dark shades correspond to longer life times. Stable MMRs that produce large TTV signals are also shown.

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Textural features and isotopic ratios of the magmatic and inherited zircons in the mafic migmatites from the Takab core complex, NW Iran

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U-Pb isotopic data from the Takab migmatite suggest two types of inherited and melt grown zircons. We interpret that the young zircon (c. 25 Ma) is newly grown grain whereas the old zircon (2961±72 Ma) is inherited. Zircons in various parts of the investigated migmatites are different in the view of grain size, modal abundance and morphology. We interpret scarce zircon in the mesosome due to mafic composition of the protolith or existence of Zr-bearing phases such as hornblende and ilmenite, hindering zircon crystallization in these parts. Newly crystallized zircon in mesosome may have been crystallized from the melt which was not extracted. Melt grown zircon in melanosome and leucosome occurs as large newly grown unzoned crystals. They are commonly subhedral to rounded, scarcely preserved perfect euhedral shapes. The rounded edges of the prismatic zircon grains suggest *in situ* re-crystallization rather than by precipitation from a melt. The newly formed zircon in the investigated rock has variable Th/U ratios ranging from 0.20-1.10. High Th/U ratio is typical feature of melt grown zircons.