Relaxation process of regolith-covered terrains induced by vibration

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Many rocky planets are covered with a layer of loose granular matter called regolith. Granular matter presents the wide class phenomenology of complex fluids, which is thought to be an origin of peculiar planetary surface terrains. Particularly, in the case of small asteroids, it has been reported that regolith grains fluidized by meteorite-impact-induced seismic waves (e.g., [1]) cause the relaxation of surface terrains such as craters [2]. In order to understand the dynamics, Roering et al. have presented the transport law of a vibrated granular flow that depends only on terrain slopes [3]. However, the granular flow properties in general depend on vibration conditions and grain properties as well. Motivated by these considerations, we experimentally clarify the vibration condition in which terrains consisting of granular media are fluidized, and then aim to construct the model that describes the flow properties of fluidized grains.

Experimental procedures are as follows: A sandpile having the angle of repose is made on a disk pasted with the same kind of grains. Then, sinusoidal vertical vibration is continuously applied to the system. During the vibration, the relaxation process of the shape of a sandpile is recorded by using a laser profiler.

According to the observations in experiments, the fluidization occurs when the maximum vibration acceleration exceeds the gravitational acceleration. In the analyses, relations between the flux and the slope of a heap are measured at a variety of time. As a result, the relation can be described by the phenomenologically-derived transport model on the basis of Ref. [3]. In this model, the thickness of a flowing layer is determined by the local height of a heap, whilst the transport velocity is detemined by the local slope of a heap, the granular friction coefficient, and the velocity characterizing the vibration strength. Then, from the experimental results obtained in various conditions, the characteristic velocity is found to be proportional to the maximum velocity of vibration.

In summary, by combining experiments and theoretical considerations, we have derived the transport law to describe the flux of a flow on a heap under vibration. In this relation, the thickness of a flowing granular layer is determined by the height of a sandpile , which is constrained by the experimental system size. Therefore, assuming that its thickness corresponds to the thickness of a flowing regolith layer, the vibro-relaxation dynamics of regolith-covered terrains would be described by the transport model proposed in this study.

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