IMPACT CRATER SCALING LAWS

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Impact craters are numerous on planetary bodies and furnish important information about the composition and past histories of those bodies. The interpretation of that information requires knowledge about the fundamental apects of impact cratering mechanics. Since the typical conditions of impacts are at a size scale and velocity far in excess of experimental capabilities direct simulations are precluded. For that reason, one must either rely on extrapolations from experiments of relatively slow impacts of very small bodies, using physically based scaling laws, or must study the actual cases of interest using numerical code solutions of the fundamental physical laws that govern these processes.

This is a progress report on research on impact cratering scaling laws, on numerical studies that were designed to investigate those laws, and on various applications of the scaling laws developed by the author and his colleagues.

Previous work has showed that the basis for all common cratering scaling laws is that the impactor radius a, velocity U and mass density δ occur in those scaling laws as a single combined measure of the form $aU^\mu\delta^\nu$, where the exponents μ and ν vary between different scaling laws. This single measure has been termed a coupling parameter, since it measures the coupling of the energy and momentum of the impact into the planetary body. [1]   Previous applications of the theory and scaling laws based on this coupling parameter have been reported. [2-7]

Recent theoretical studies [6] have exposed the reason that such a single measure can be used to characterize the impact: the important phenomena that give the final obserable crater occur at a distance from the impact point that is fairly large compared to the impactor size itself. As a consequence, those phenomena are the same as would occur for the deposition of the finite impactor energy and momentum at a single point; and are therefore governed by a "point source" solution. Point-source solutions of various types that are related to various impact conditions exist and have been studied and extended in this research. One of the more important is for a point source in an ideally porous material, since that model represents fairly well the mechanical behaviours of common soil-like materials. Those solutions, as well as others, have been reported in [8].

The assumption that a point-source approximation can be used to measure an impact, together with appropriate assumptions as to the mechanisms that absorb the energy and momentum of the impactor allows one to generate specific scaling laws, for all aspects of the cratering processes that occur sufficiently far from the impactor so that the assumption is in fact valid. The recent paper [8] presents a large number of scaling results derived in this way. These include not only results for the final crater size, but also for dynamic phenomena such as crater growth histories and formation times. A different paper [9] looks at the application to the volume of melt that occurs at sufficiently high impact velocities.

Recent code calculations of impacts into porous half-space targets have also been studied to obtain confirmation of the scaling forms and to obtain specific numerical exponents of those forms. Those calculations are also reported in [8].

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