ON THE EXISTENCE AND IMPLICATIONS OF COUPLING PARAMETERS IN CRATERING MECHANICS

by

K. A. Holsapple
University of Washington FS-10
Seattle, WA 98195

A goal of studies of impact and explosive cratering over the last two decades has been the identification of a simple measure of the impactor or explosive source that characterizes the source for late-time observables such as crater geometry and ejecta blankets. This search has been fueled by the realization that in most cases, the details of the early-time energy transmission are obscured at times when the resulting shock wave has progressed away from the source a distance of several source radii. Such description of the source, i.e., a "coupling parameter" is known to exist in the case of an explosive source in a whole-space perfect-gas media. Since the fundamental studies by Sedov (1) and by G. I. Taylor (2) it has been known that problems of this type rapidly approach a point-source self-similar solution in which the sole measure of the explosive source is the total energy E. Thus, there is a coupling parameter in those problems: the source total energy E.

Early numerical and experimental studies of impact into metal half-space targets led to the alternate claims that either the impactor kinetic energy E or its momentum M sufficed as the coupling parameter. The choice between these rather diverse hypotheses was debated for some time. In recent times the momentum advocates have faded, but the energy choice continues to be popular with numerous authors, usually without specific mention or justification.

The revival of the study of coupling parameters (3) was motivated by rather remarkable experimental results of both explosive and impact cratering into dry sand. These results showed that the crater volume dependence upon the independent variables of source energy E, specific energy Q (velocity for impact problems), and gravity g was an (almost) exact power-law dependence over many multiple decades of source energy E, ranging from (in the impact case) gram-sized projectiles to megaton-sized impactors (4). The reason for this power-law dependence and the recognition that it is the late-time evidence of the existence of an early-time coupling parameter has been reported previously (3).

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The coupling parameter concept generalizes and unifies a number of approaches in the literature. These cases include implicit assumptions about the dependence on the impactor conditions such as the energy and momentum assumptions mentioned above. In addition, many of the assumptions about the early-time flow fields such as the self-similar solutions of perfect gases, the more general point-source, nonself-similar solutions for solids discussed by Rae (5) and the rather special power-law self-similar, steady flow described by the so-called Z-model (6) are related.

In all cases of a coupling parameter, a number of significant results are obtainable. These include specific results on crater geometry scaling including specific dependencies on impactor size, velocity, gravity, and on media strength. Further, any one of these dependencies determines all the others.

Comparisons of these predictions with experimental results in wet and dry sand (7), in water (8), and in viscous targets (9) will be presented. Specific results on ejecta scaling and a comparison with experiments will be presented at this conference by Housen (10).

References

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