# THE EVOLUTION OF DUST IN THE MULTIPHASE INTERSTELLAR MEDIUM

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## I. Introduction

Interstellar dust has a profound effect on the structure and evolution of the interstellar medium (ISM) and on the processes by which stars form from it. Dust obscures regions of star formation from view, and the uncertain quantities of elements in dust makes it difficult to measure accurately the abundances of the elements in low density regions. Despite the central importance of dust in astrophysics, we cannot answer some of the most basic questions about it: Why is it that most of the refractory elements are in dust grains? What determines the sizes of interstellar grains? In our theoretical investigations we have addressed these questions by studying the destruction of interstellar grains.

We describe here the investigations that we have completed to date. As part of our original proposal we proposed additional projects that have not been completed. We are requesting a no-cost extension to carry out those investigations and describe those in our request.

## II. Destruction and Dynamics of Large Interstellar Grains in Shocks

Large (> 1 micron) grains have been thought to be very rare in the interstellar medium based on assumptions about the total mass of elements tied up in grains and the dust size distribution. Observations of dust in the Solar System, both in "pre-solar" grains found in meteorites and in direct observations of grains by the Ulysses and Galileo spacecrafts (Gruen et al. 1994), however, have revealed the existence of such grains in unexpectedly large numbers. The large mass of these grains and correspondingly large gyroradii lead to a large penetration depth beyond the shock front, i.e. the grains effectively decouple from the gas leading to complex grain dynamics and substantially altered grain destruction as compared to smaller grains. Using the codes developed by Jones et al. (1994) to calculate the grain destruction and disruption, we have investigated the dynamics and destruction of grains of a variety of types and sizes in shocks.

In addition to finding, as we expected, that large grains do decouple from the gas reducing their destruction, we found a number of surprising and important results:

- the level of decoupling is very shock speed dependent,
- for a range of shock speed and grain size, the grains are reflected back into the pre-shock gas leading to multiple reflection and acceleration to high speeds before being destroyed, possibly leading to a source for cosmic rays, for some of the largest grains studied (¿ 1 micron) the decoupling protects them from destruction and they pass through the shock and "escape" into the hot, low density supernova or superbubble gas behind the shock. With a significant fraction of the dust mass contained in grains larger than 0.1 microns, it is critically important that grain trajectories be calculated in order to assess the level of destruction accurately in interstellar shocks.

## III. Summary

We have undertaken studies of the ISM in order to understand dust evolution. To date we have completed the modeling of the destruction and dynamics of large grains in shocks. These investigations suggest that many large grains and even smaller grains may survive shock passage with relatively little destruction. Our results suggest several new avenues for further studies of grain evolution as well as presenting a possible solution to the "overdestruction" problem for interstellar dust.

Our completed investigations have given us insight into the nature and evolution of dust in the diffuse ISM. Interstellar dust is intimately linked to the structure and evolution of the ISM and our modeling efforts will have significant implications for the ISM as a whole. Our models will have direct applications for the interpretation of the spectral characteristics of the ISM, in particular SNR shocks, and the Local Cloud.

## References


Gruen, E., Gustafson, B., Mann, I., Baguhl, M., Morfill, G. E., Staubach, P., Taylor, A. & Zook, H. A. 1994, A&A, 286, 915

Jones, A. P., Tielens, A. G. G. M., Hollenbach, D. J., & McKee, C. F. 1994, ApJ, 433, 797