COMPUTER SIMULATION OF DUST GRAIN EVOLUTION

K. Liffman, NASA Ames Research Center, M.S. 245-3, Moffett Field, CA 94035

We present a status report on the latest results obtained from a Monte Carlo code that is being developed at NASA Ames. The goal of this program, is to derive from the observed and presumed properties of the Interstellar Medium (ISM) the following information:

(1) The size spectrum of interstellar dust

(2) The chemical structure of interstellar dust

(3) Interstellar abundances

& (4) The lifetime of a dust grain in the ISM.

Clearly a sample of a comet would allow us to compare theory with reality - at least for the first two of the four listed goals.

Presently our study is restricted to refractory interstellar material, i.e. the formation and destruction of ices are not included in the program. The program is embedded in an analytic solution for the bulk chemical evolution of a two-phase interstellar medium in which stars are born in molecular clouds, but new nucleosynthesis products and stellar return are entered into a complementary intercloud medium. The well-mixed matter of each interstellar phase is repeatedly cycled stochastically through the complementary phase and back. Refractory dust is created by thermal condensation as stellar matter flows away from sites of nucleosynthesis such as novae and supernovae and/or from the matter returned from evolved intermediate stars.

The history of each particle is traced by standard Monte Carlo techniques as it is sputtered and fragmented by supernova shock waves in the intercloud medium. It also accretes an amorphous mantle of gaseous refractory atoms when its local medium joins with the molecular cloud medium. Finally it encounters the possibility of astration (destruction by star formation) within the molecular clouds. This scenario is presented schematically in fig. 1 and actual data from a case run where the grains were allowed to fragment into one hundred pieces whenever there was a grain-grain collision are presented in fig. 2. It should be noted that in fig. 2 any grains smaller than 5 Å are considered to be gas molecules.

injection size spectrum

Fig. 1

$N(a)$

a^{-3}

100 Å 1000 Å a

Galactic Evolution

Evolved Size Spectrum

$N(r)$

Inter-cloud

Molecular Cloud

100 Å 200 Å r

homogeneous composition

Two phase Interstellar Medium

Inter - Cloud   Molecular Cloud

r = a

Sputtering → Accretion

τ

grain collisions Astration

←

$100Å < a < 1000Å$

transfer of material

Evolved diffuse cloud particles

core

bare initial core

mantle

gas

mantle and core collision fragments

$t_{final} = 6 \times 10^9$ yr

50000

$y = 2.6e4 \, exp(-x/100)$

40000

Fig. 2

30000

in Molecular and
Inter-Cloud mediums

20000

10000

0

0   50   100   150   200   250

radius (Å)

• # in M.C.
+ # in I.C.