DEVELOPMENT OF A VIRTUAL SCATTERING LABORATORY SOFTWARE PACKAGE TO STUDY THE OPTICAL PROPERTIES OF COSMIC DUST AGGREGATES

Kimadri Sekhar Das
Department of Physics, Assam University, Silchar-788011
hadass@uacce.ernet.in

ABSTRACT

The following paper reports the development of a virtual scattering laboratory software package to study the optical properties of cosmic dust aggregates. This package consists of a Graphical User Interface (GUI) in the front hand and a database of related data on the back hand. Both the interactive GUI and database package directly enables an astronomer to model by simulating its respective input parameter (viz. wavelength, complex refractive index, grain size parameter, etc.) to study the related optical properties (viz. Extinction, Polarization, etc.) of cosmic dust (interstellar dust, interplanetary dust, circumstellar dust, interstellar dust) interactively, i.e. with zero computational delay, which directly increases the efficiency of the user. The database of different optical properties of the cosmic dust aggregates is generated in a very wide range using many leading mathematical models available (Supersposition T-Matrix code, Discrete Dipole Approximation code) with high computational accuracy. This package also has an option where users can compile and run the scattering code directly for aggregates in GUI environment.

INTRODUCTION

Cosmic dust is a type of dust composed of particles in space which are irregularly shaped with porosity ranging from fully to compact. Cosmic dust can be distinguished by its astronomical location at, (a) interstellar dust, (b) interstellar dust, (c) interstellar dust and (d) circumstellar dust. In our solar system, interstellar dust causes the reddish light. Sources include cool dust, asteroidal dust, dust from the Kupier belt and interstellar dust passing through our solar system. It has also been suggested that cosmic dust granules may consist primarily of regular shapes and flat structures, with a mixture of various chemical compounds. (Voshchinnikov & Binns 1999; Krause & Binns 2004 etc.). It is now well accepted from in-situ measurements of comets and Ockehedreterrestrial sources of Galactic and interstellar dust consists of a mixture of carbonaceous particles and aggregates (Fornelikuke et al. 1999; Horz et al. 2000; Zolensky et al. 2000; BURLESON et al. 2008 etc.).

AGGREGATE DUST MODEL

In the present work, aggregates have been built using ballistic aggregation procedure (Klausing, 1963, 1984). Two different models of cluster growth are adopted: (a) single-particle aggregation and (b) through cluster-cluster aggregation. These aggregates are built by random hitting and sticking particles together. When the procedure allows only single-particle to join the cluster of particles, the aggregation is called Ballistic Particle-Cluster Aggregation (BPCA), and if the procedure allows clusters of particles to stick together, the aggregate is called Ballistic Cluster-Cluster Aggregation (BCCA). In Fig. 2, the BPCA-aggregates with 128 monomers are shown, respectively. Usually the BPCA clusters are more compact than BCCA clusters (Makus et al. 1965). The porosity of BPCA and BCCA particles of 128 monomers has a value of 0.05 and 0.04, respectively, and the fractal dimension of BPCA and BCCA is D = 3 and 2, respectively. The studies of interstellar and cometary dust indicate that cosmic grains are likely to be porous, fluffy and composed of small grains connected together due to grain-grain collisions, dust-grain interaction and various other processes. Porous, composite aggregates are often modeled as cluster of small spheres (microner) assembled under various aggregation rules with typical sizes of 0.5-10 mm.

LIGHT SCATTERING PROPERTIES OF AGGREGATE PARTICLES

Interplanetary and interstellar dust particles are commonly believed to include aggregated structures of simple morphology. Optical properties of these particles have been extensively investigated through the use of various numerical techniques. The Discrete Dipole Approximation (DDA) code (Draine & Flatau, 1994, 2013b and Draine & Flatau, 1998, 2001) is widely used by astronomers and astrophysicists to study the light scattering properties of cosmic dust aggregates. We presently use Superposition T-Matrix approach in our software package. Aggregate dust model has been extensively used by several investigators to study the light scattering properties of cometary dust (Kimura et al. 2005, Das et al. 2008b, 2009b, 2010b) assuming an individual cometary grain to be an aggregate of several monomers. Das et al. (2008b) analyzed the observed polarization data of Comet C/1995 O1 LINEY and successfully reproduced the polarization curve using Monte-Carlo. Das et al. (2008b) successfully reproduced the polarization characteristics of Comet C/1999 S4 Horst using a 10000 monomer head.3

ASSAM UNIVERSITY VIRTUAL SCATTERING LABORATORY SOFTWARE PACKAGE (AUvSLab)

AUvSLab has been developed by us at the Department of Physics, Assam University, Silchar (INDIA) to build a user-friendly graphical user interface (GUI) environment to study the optical properties of cosmic dust aggregates using Microsoft Visual Studio 2010. Microsoft Visual Studio (URL:www.microsoft.com/visualstudio/en-us/products) is an integrated development environment that can be used to develop concise and graphical user interface applications along with Windows Forms applications, web sites, web applications, and web services in both native code together with managed code by a programming language supported by Microsoft Windows, Windows Mobile, Windows CE, .NET Framework, .NET Compact Framework and .NET Framework Development Kit. This package comprises a Graphical User Interface (GUI) which pre-processes the database of related data on the back hand. The interactive GUI and database package directly enables an astronomer to model by simulating its respective input parameter (viz. wavelength, complex refractive index, grain size parameter, etc.) to study the related optical properties (viz. Extinction, Polarization, etc.) of interstellar dust, i.e. with zero computational delay, which directly increases the efficiency of the user. The virtual scattering T-Matrix code from many leading scattering codes related to the optical properties of the cosmic dust aggregates is generated in a very wide range using Superposition T-Matrix codes with high computational accuracy. The intuitive GUI makes the convenient interaction of both theoretical and observational experiment data much easier. This package also has an option where users can compile and run the scattering code directly for aggregates in GUI environment. It also uses FORTRAN compiler to run the code and SKYPLLOT software package to plot the output file in addition to Visual Studio 2010.

CONCLUSION

We develop a light scattering software package Assam University Virtual Scattering Laboratory Software Package (AUvSLab) which uses Supersposition T-Matrix code. It has been developed by us at the Department of Physics, Assam University, Silchar (INDIA) to build a user-friendly graphical user interface (GUI) environment to study the optical properties of cosmic dust aggregates using Microsoft Visual Studio 2010. It is to be noted that AUvSLab is now developed only for WINDOWS environment. It is also planned to develop the package in other environments.

REFERENCES

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