

# Preface

Holding a tiny piece of a star in one's hand might seem like an impossible dream. Today, however, it is a reality. Microscopic dust grains manufactured around stars that existed before our solar system formed, are now extracted from meteorites that have fallen to the Earth, and analysed in terrestrial laboratories. The stellar origin of this dust is revealed by its exotic composition, much different from that of the bulk of the material in the solar system.

Although the analysis of stellar grains is a very young field – it was born in 1987 – much has already been achieved, especially since recent advances in laboratory techniques have allowed to perform analysis of grains of size smaller than a micrometer, and high-precision measurements of the composition of elements present in trace in the grains. Soon, it will be possible to collect data on the composition of many different elements in single dust grains of many different types. In some instances, the technological advances have been so rapid that the theoretical interpretation can barely keep up with the flow of new information.

The aim of this book is to present issues related to stellar grains in an accessible way, thus helping students and scientists at all levels and of all backgrounds to learn about this field. Indeed, a broad awareness about stellar grain research and its implications is still lacking in the astronomy community at large, mainly because the subject is so new, and different when compared to anything that has been studied before. Both researchers and students need a broad basic knowledge and a clear presentation of the tools needed to familiarise themselves with presolar grains.

In spite of the vast amount of information that stellar grains yield about the different sites and processes that affect their features during their life – from the formation of dust around stars, to the survival of dust in the inter-

stellar medium, to the formation of our own solar system – the focus here is on using the grains as evidence of the processes related to the evolution of stars and to the nuclear reactions that change their composition throughout their lives (*nucleosynthesis*). In this respect, when confronted with the data coming from grain analysis, the problem is two-fold: on one hand we want to satisfy our immediate curiosity of answering the grain puzzle: How did their unusual compositions come about? On the other hand, we want to use the data as a tool in the wider task of understanding stars and explaining how they have been producing the elements that constitute the Universe, including ourselves and our environment. For this task, stellar grains represent a breakthrough. They have recorded the composition of stars, and their analysis yields data of extremely high-precision: error bars are as low as 1%, as compared to the spectroscopic observations of the composition of stars, which are affected by uncertainties of approximately 50%. Paraphrasing Clayton & Nittler [68], two- or three-dimensional diagrams representing the composition of stellar grains could have a similar use for the classification of nucleosynthesis processes, as the Hertzsprung-Russell diagram has for the classification of stars.

Even confining the discussion of this volume to the impact of the analysis of stellar grains on studies of stellar evolution and nucleosynthesis, it has not been feasible to cover in detail all of the many issues. Instead, the focus is on one particular type of stellar grain, silicon carbide (SiC), since these grains have been the most extensively analysed to date, and on one particular type of stellar source, Asymptotic Giant Branch stars, which appear to be the producers of many of the stellar grains recovered to date. This focus stems from my own expertise in the subject and from a wish to offer the reader detailed examples, displaying the level of sophistication of the implications of the study of presolar grains. Other types of grains and stellar sites would also be extremely interesting to discuss in detail, for example grains that are believed to have originated from supernova explosions. A large extension of the book would be necessary to treat these other topics properly. In any case, an introduction and references are given for all the issues that are not discussed in detail.

The future of stellar grain studies is dynamic and exciting: many puzzles are far from being solved and many more will come to challenge us.

The book is divided into six chapters, of which the first three provide an overview of the topic and of related basic information. The following three chapters are, instead, more specific and thus represent a more complex reading. They can be used to deepen the understanding of the origin of the

different types of grains, and of the different types of information that it is possible to extract in relation to nucleosynthesis processes in stars. Each chapter is equipped with a set of exercises, of which detailed solutions are given in Appendix B. Appendix A provides the reader with a general simple glossary, which should be useful to consult to clarify a word or expression, while reading the main text, or to remind oneself of their meaning. A set of selected references are given in Appendix C.

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