Comets and their Origin

Comets are very primitive objects that formed far away from the sun, and therefore provide important clues about the formation of the solar system. These celestial objects might also be related to our own origin: the appearance of the first life forms could have been triggered by asteroid/comet impacts on the primitive earth. In addition, the close passage of a comet displaying its colorful tails is probably the most exciting event that we can see in the night sky. Thus, it is no wonder that comets have such a tremendous attraction for us. Recently, the soft landing of Philae, the module on board Rosetta, on a comet became a trending topic all over the world.

The publication of this book in late 2014 was very timely for the ESA Rosetta cometary mission. Comet 67P/Churyumov–Gerasimenko (henceforth abbreviated as 67P) was approached during the summer of 2014, and Philae landed on the comet nucleus on 12th November. Despite the abnormal landing, which placed Philae in a dark area of the comet, this module is currently resting on 67P, and Rosetta is orbiting this small body of our solar system as it gets closer to the sun. Most of the scientific program planned for Rosetta was greatly fulfilled, and more results are expected during this year. In general, the orbiter is still working nominally, and Philae is waiting for a second chance to measure the comet surface, provided that the batteries are sufficiently charged this summer.

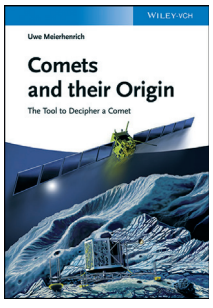
This book provides the necessary information to interpret the results obtained by cometary missions such as Rosetta. It is written in a very direct and didactic manner, making it accessible to all the scientific community, which is an imperative in the multidisciplinary field of cometary science. I have known the author since our collaboration for the COSAC–Rosetta instrument in 1998, which led to the identification of amino acids among the refractory products made by UV irradiation of pre-cometary ice analogs. At that time, I was a PhD student working in laboratory astrophysics and Uwe Meierhenrich was a postdoc specializing in analytical chemistry and chirality; he was eager to learn everything about comets and astrochemistry. The broad scientific background of the author is essential to cover the topic of comets from different perspectives.

The first part of the book comprises Chapters 1 to 4, and serves to review the current knowledge on comets and related topics. Chapter 1 provides a general introduction to comets and cometary missions previous to Rosetta. Chapter 2 discusses the formation of comets, describing the existing models of cometary nuclei; it also introduces the analytical tools used to characterize the cometary composition, and thus to infer some clues about their origin. While Chapter 3 focuses on water and on organic matter of astrobiological significance in comets, with the help of laboratory simulations of interstellar ice processes, Chapter 4 deals with the chirality of biomolecules. Both chapters act as a preamble to the in situ analysis of cometary organics by the Rosetta instrumentation; in particular the COSAC gas-chromatograph–mass-spectrometer is equipped to detect enantiomeric excesses in chiral compounds.

The second part of the volume is devoted to the Rosetta mission. Chapter 5 is a brief history of the mission before the launch in 2004. Chapter 6 continues the history of Rosetta, up to the wake-up on 20th January 2014 that followed hibernation. Two asteroids, Šteins and Lutetia, were approached by the Rosetta spacecraft and examined with the different instruments. Chapter 7 presents the sequence of events during the rendezvous of Rosetta with the comet, the instrumental capabilities, and the expected scientific results of the mission. Chapter 8 briefly reports some of the technological improvements that are a result of the Rosetta mission and the future of cometary science.

The most exciting side of this book is its potential to predict the findings of a cometary mission, or at least to put in perspective the scientific value of Rosetta by comparison to previous missions. Fortunately for us, this exercise can now be attempted, since the first scientific work of Rosetta was successfully completed. It was indeed very satisfactory to go through the pages of the book searching for information that helped to interpret the recent Rosetta data, or just to check whether our current view of comets has to be revised. I personally became very excited when comparing the current inventory of cometary species to the list of molecules present in the dusty surface of 67P, which we inferred from the data of the COSAC–Rosetta instrument after the first landing. No less exciting was the observation that those molecules seem to coincide with some of the products made by irradiation and warm-up of pre-cometary ice analogs. The reader will be delighted to use this book as a guide for his/her own research interest within the field of comets.

Let us now put some of the new Rosetta results in perspective with the help of this book. The detection of organic molecules in the dust of 67P will undoubtedly remain as one of the key findings of the Rosetta mission, along with the long list of molecules observed in the gas phase as the comet reaches perihelion, the high deuterium-to-hydrogen value detected in water molecules as an indication of a pristine material formed at cryogenic temperatures, the unprecedented images of



Comets and their Origin
The Tools to Decipher a Comet. By Uwe Meierhenrich. Wiley-VCH, Weinheim 2014. 352 pp., hardcover, € 125.00—ISBN 978-3527412815

its two-lobe surface showing mountains, craters, boulders, or the lack of a magnetic field in this comet, and a long "etcetera". The dust covering almost the entire surface of 67P immediately got much attention, and many of us wondered about its origin. The most plausible answer can be found on page 7 of this book: according to Rickman and Huebner, there is a maximum size of dust particles that can be lifted from the comet nucleus depending on the comet activity. In the case of 67P, dust accumulates on the surface during its orbital period of 6.5 years until a maximum release of the dust is reached close to perihelion. Also significant was the possibility that Jupiter-family comets may have originally been long-period comets with trajectories that were altered by the gravitational force of Jupiter, which suggests that 67P could have been formed very far away from the sun. This is compatible with the high deuterium content measured by the ROSINA mass spectrometer on the Rosetta orbiter. In summary, we can feel fortunate that Rosetta delivered plenty of unprecedented scientific results, that there are more exciting findings to come along in 2015, and that 67P is an active comet with everything in it—ice, minerals, and complex organic matter—that seems to be more pristine than previously thought. This book, with the numerous references that it contains, is the perfect tool to guide us along the way of cometary exploration and the sequence of multiple origins: solar system—ice and dust—chirality—complex organics—comets—planets—early life—us.

Guillermo Manuel Muñoz Caro
Center of Astrobiology (INTA-CSIC)
Torrejon de Ardoz, Madrid (Spain)

International Edition: DOI: 10.1002/anie.201503887
German Edition: DOI: 10.1002/ange.201503887