

A plain man's guide to the cometary environment

L. M. CELNIKIER AND N. MEYER

Comets, volatile bodies whose environment depends on their distance from the sun, are presented in a way which highlights the essential physical processes involved. The contributions of past space missions such as Giotto and VEGA are discussed, as well as the potential benefits which might accrue from future missions such as CRAF.

1. Introduction

What is a comet?

Etymologically comets, 'hairy things', owe their name to their visual appearance as compact objects – 'heads' – trailing a long and diffuse structure. This structure is not permanent; it grows as the comet approaches the sun and dies away as the comet recedes, and we shall see that its very existence already furnishes a clue as to the typical size that the 'head' must have.

To each specialist his comet. To the planetologist searching for clues about the origin of the solar system, a comet is a potential source of information about primordial conditions in the 'solar nebula', and how this material evolved into the system we see today; to the gas phase chemist, the cometary atmosphere is a marvellous 'kitchen' in which to study the way exotic chemical processes take place in the presence of ionizing radiation; solid state experts extract much fun from building models of the solid material; in the cometary environment, the plasma physicist finds a strange medium in which ionized material is mixed with dust, the whole interacting with the interplanetary medium and its magnetic field in ways virtually impossible to simulate in the laboratory; finally, comets can be used as 'tracers' to study other problems, such as the general conditions of the interplanetary medium, or the mechanics of the complex gravitational field of the solar system.

Naïvely, one might think of a comet as a kind of very tiny planet; however, whereas a given planet is always embedded in much the same interplanetary medium and has a virtually unchanging radiation budget, comets, whose orbits are highly elliptical, are subject to continuously changing external conditions. This funda-

mental difference allows one to think of comets as compact and generally invisible sources of diffuse material, whose behaviour and appearance are driven by particular boundary conditions: this is the *leitmotiv* of this paper.

In short, we shall not explain *what* a comet is, rather investigate the physics which makes it look the way it looks. And figure 1 is a remarkably clear, albeit old, drawing of how a comet looks – it shows Donati's comet on the 5th of October, 1858, over Paris. The view is roughly west in the early evening (as one can see from the traffic on the bridge). Donati's comet was an admittedly spectacular object, rated as one of the best of the century; in particular, one can distinguish essentially two classes of tail, one class straight (itself doubled), pointing towards where the Sun set, the other curving away – even in this sketch, one has the feeling that the two tails must be of a totally different nature. A reasonably knowledgeable amateur astronomer will immediately recognize some of the constellations and deduce the angular scale of the drawing, from which he will find that the tails extend over roughly 30°; since at that date, the comet was about ninety million kilometres from the Earth, the tails turn out to be about fifty million kilometres long, a quite respectable distance. And the separation between the two straight tails is about one tenth of the length.

Finally, this drawing suggests that the cometary environment is surely very tenuous: the stars can be seen *through* the tails.

Modern spectroscopic observation adds one other fundamental piece of information: the spectrum of the curved fan-shaped type of tail is dominated by a continuum similar to that of the Sun, suggesting the reflection and diffraction of light, while the straight tails are sources of emission lines, indicating the presence of an excited gas.

Authors' address: Observatoire de Paris, 5 Place Jules Janssen, 92195 Meudon Principal Cedex, France.