Chapter 1

Comet Hale-Bopp

Comet C/1995 O1 (Hale-Bopp) was discovered on the night of July 22, 1995, almost simultaneously by Alan Hale and Thomas Bopp. While Alan Hale is a professional astronomer, Thomas Bopp is an amateur astronomer. Both were actually planning to observe deep-sky objects in M70 when they noted a fuzzy patch which was moving relative to the star background. At the time of discovery the comet was at a heliocentric distance of 7.15 AU and a geocentric distance of 6.2 AU. Hale-Bopp had a visual magnitude of 10.5. No comet before has been discovered so far out in the solar system by an amateur astronomer. Hale-Bopp appeared 1000 times brighter at its discovery beyond Jupiter's orbit than comet Halley did when it was at the same distance from Earth.

Figure 1.1: Hale-Bopp at perihelion (Photography by Nicola Biver)

The comet reached its perihelion on April 1, 1997 at a heliocentric distance of 0.9141 AU. Unfortunately the comet was at this time not visible from Earth. Closest approach to Earth was on May 22, 1997, with a geocentric distance of 1.3 AU. At this time Hale-Bopp was easily visible with the naked eye. The picture in figure 1.1 was obtained at this time by

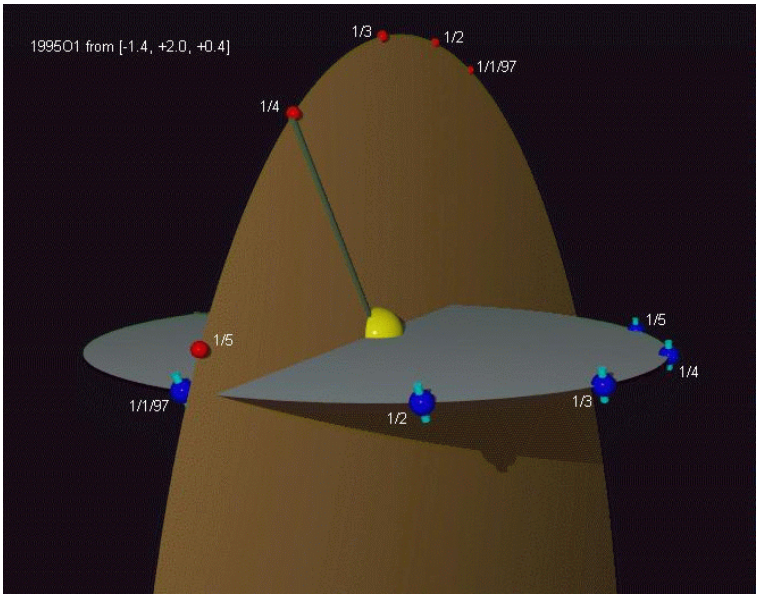

Figure 1.2: Orbit of Hale-Bopp around perihelion (Presentation by JPL Solar System Group)

Nicola Biver with a regular SLR camera near Meudon in France.
The following table gives a summary of some general information about the "Great comet of 1997".

Orbital inclination:	89.43 deg
Orbital eccentricity:	0.9951
Argument of perihelion:	130.59 deg
Longitude of ascending node:	282.47 deg
Perihelion distance:	0.9141 AU
Perihelion date:	April 1, 1997, 3:19 UTC
Closest approach to Earth:	1.3 AU
Date of closest approach to Earth:	March 22, 1997
Next perihelion:	$\approx$ 2380 years
Last perihelion:	$\approx$ 4200 years

Figure 1.2 shows the orbit of comet Hale-Bopp around perihelion and the position of the Earth. The position of Hale-Bopp and Earth are plotted in one month steps. The blue line indicates the perihelion position on Hale-Bopp. The comet was an ideal target for observers on the northern hemisphere.
Hale-Bopp revealed a straight tail of sodium atoms, almost 6 degrees long [Cremonese *et al.*, 1997]. The picture in Figure 1.3 was obtained with a filter centered on the Na D lines (at 5892 and 5898 Å). The direction of the sodium tail is very close to the antisolar direction, because sodium atoms are quickly accelerated by solar light. The origin of cometary sodium is still not fully understood. It might be that sodium-bearing molecules are released from

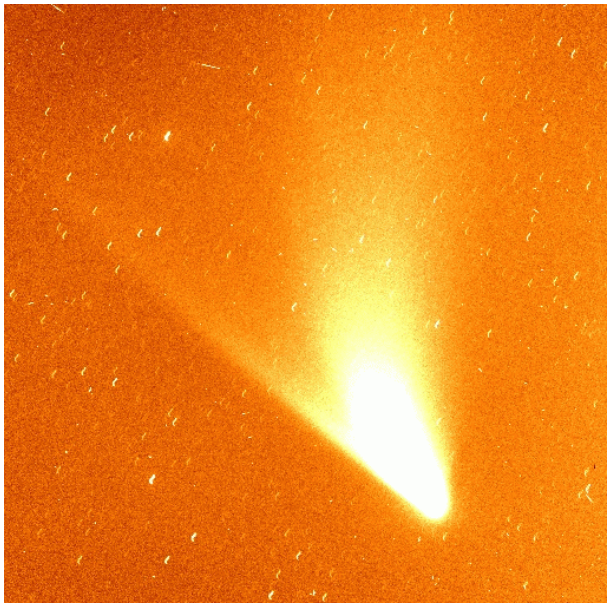

Figure 1.3: Sodium tail of Comet Hale-Bopp observed on April 16, 1997 with the INT telescope at La Palma. From Cremonese *et al.* [1997]

the nucleus, but this will be the subject of further studies. For more details see Cremonese *et al.* [1997].
In comet Hale-Bopp six new species have been identified for the first time in a comet. Table 1.1 lists the molecules and their relative abundance to water (from Bockelée-Morvan *et al.* [2000])

Molecule	Abundance to water
SO	0.3%
SO_2	0.2%
HC_3N	0.02%
NH_2CHO	0.01–0.02%
HCOOH	0.09%
OCS*	0.4%
HNCO*	0.1%

Table 1.1: New molecules detected in comet Hale-Bopp and their abundance relative to water. Molecules marked with an asterisk have been detected in comet Hyakutake and the detection has been confirmed in comet Hale-Bopp

Comet Hale-Bopp was a very active comet. Dello Russo *et al.* [2000] measured a water production rate of about Q=$1 \cdot 10^{31}$ molecules s^{-1} at perihelion. As a comparison for comet Halley a water production rate of Q$\approx 5 \cdot 10^{29}$ molecules s^{-1} at 1 AU was measured by Fink and Disanti [1990]. Comet Hale-Bopp was also a very dusty comet with a dust to gas ratio of about 5 at perihelion [Jewitt and Matthews, 1999] and about 3-5 at larger heliocentric

distances (Rauer *et al.* [1997] and recently Weiler [2002]). The extraordinary activity of this comet combined with the advances in instrumentations at the telescopes gave a boost to cometary science and made studies like the one presented here possible.