Plasma Tails: Comets Hale-Bopp and Hyakutake

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Fig. 1. Comet Hale-Bopp exhibited both a spectacular bluish plasma tail, and a whitish dust tail. This photo was taken from a dark sky location near Roseburg, Oregon, at 0400 UT, April 5, 1997, using a 12 minute exposure on Kodak ASA 1000 film, and an f4 135 mm telephoto lens. The cluster of stars above the comet head is M34, and the plasma tail is ~ 9º long.

***Abstract*–Comet Hale-Bopp was one of the largest comets ever recorded, and it exhibited both a massive dust tail and a plasma tail, which developed as it approached the sun over the course of six months in 1996-1997. Because the dust responds to gravity and light pressure, but plasmas also respond to the local solar wind (Coulomb collisions and magnetic fields), there is typically an angular separation between the two tails, as seen in the photo above.**

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COMETS have long fascinated humanity, undoubtedly since even before writing was invented. Their appearance in the sky has been blamed on many things, ranging from angry gods to evil omens[1], and only in the last 150 years have scientists come to understand them as icy and dusty travelers from the frozen realms beyond Pluto. Fortunately, as 20th century amateur astronomers, we have had the pleasure of observing a number of comets since the

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early 1970's, including Comet West (1976), Halley's Comet (1986), Comet Shoemaker-Levy-9 (1994), Comet Hyakutake (1996), and most recently Comet Hale-Bopp (1997)[2]. In this paper, we show images of the plasma (or "ion") tail from these last two comets.

We photographed Comet Hale-Bopp from Sept. 1996, to April 1997, as it approached the Sun, moving from 3.5 AU (1 AU = average Sun-Earth distance, or 150 million kilometers) in towards its perihelion at 0.91 AU[3]. During this time, the comet evolved from sporting a short fan-shaped dust cloud, into a twin-tailed object. The striking blue tail (seen in Figure 1) is primarily caused by CO ion emission[4]. The whitish tail is caused by sunlight reflecting off of dust, as we view it from the earth. A typical view of the western horizon, with sky-glow from Los Alamos National Laboratory and the setting sun, is seen in Figure 2. Here we used a 50 mm f1.8 lens on a fixed tripod, with a 60-second exposure of Fuji 800 film. At this time, the Sun-Comet-Earth angle was 46º, so in order to estimate the actual length of the tail, one must correct for the projection angle. All our images are developed, and then digitized with a Minolta Quickscan 35™ slide/negative scanner, before being processed on a PC with Adobe Photoshop™ software. With our equipment, we were unable to see the "third" tail, caused by neutral sodium atom emission, located between the two classic features[5].

Fig. 2. Comet Hale-Bopp dominated the western skyline in the early evening in Los Alamos during April 1997. It was 1.38 AU from the Earth on April 5, 1997.

Unlike Comet Hale-Bopp, Comet Hyakutake displayed only a plasma tail (indicating that it was relatively dust-free), as seen in the black and white wide-angle photo (8:45 UT, March 27, 1996, 60 second exposure, ASA 3200 film, f2.5, 24 mm focal length lens) shown in Figure 3. Even though Hyakutake's plasma tail was much shorter in absolute size, it spanned a greater extent of the sky (~90º from Polaris, through the cup of the Big Dipper) than did Hale-Bopp's, due to a 100x closer approach to Earth (at a distance of about 15 million kilometers).

Fig. 3: Comet Hyakutake photographed from Los Alamos, New Mexico. The bright star near the head of the comet is Polaris, and the Big Dipper (Ursa Major) can be seen oriented vertically near the end of the tail.

Further images of cometary plasmas (and earthly plasmas too!) are available on the web, at http://wsx.lanl.gov. An archive of Comet Hale-Bopp information can be found at the Jet Propulsion Laboratory, http://www.jpl.nasa.gov/comet.

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