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The Sodium Tails of Near-Sun Comets

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Abstract

In 1997, images of the very bright comet C/1995 O1 (Hale-Bopp) obtained with a wide-field imager, CoCam, on La Palma revealed that in addition to the usual dust and ion tails, Hale-Bopp possessed a tail composed of sodium atoms [1]. This distinct tail consisted purely of atoms accelerated anti-sunward by radiation pressure.

Although sodium had been recognized as being present in comets decades before Hale-Bopp, the observation of a distinct sodium tail had only been reported in one other comet: Mrkos, in 1957, and the latter observation had not been widely publicized.

Hale-Bopp's discrete sodium tail was found to be accompanied by a more diffuse sodium component apparently originating at the comet's dust tail. Other atoms, such as those of lithium, should also form distinct tails, but sodium appears to be the only easily-accelerated atom that is also relatively abundant and easily observed in the visible range. The presence of a neutral iron tail has also been proposed for C/2006 P1 (McNaught) [2].

The existence of Hale-Bopp's sodium tail spurred on several studies of the origin of this feature. Sodium is known to be a very strong contributor to the emission spectra of sungrazing comets [3]. Although it is known that there are at least two sodium sources, one near the nucleus, and another in the extended dust tail, to date, no clear solution to the ultimate source of the sodium has been identified. The study of more comets' sodium tails would greatly aid the understanding of the source of this material, and in turn, the composition of comets and the nature of their dust particles.

We present results of our survey of the sodium tails of several comets observed by the Solar and Heliospheric Observatory spacecraft, SOHO, using its LASCO coronagraph. We report on the morphology and brightness of these comets' sodium tails, using photometric analysis to estimate their relative sodium production rates.

In addition, we attempt to simulate the observed tails using a Monte Carlo model. Simulation of the tail's morphology and appearance is not straightforward; the anti-sunward acceleration of sodium atoms is a strong function of the atoms' radial velocity, due to the dependence of the acceleration on the strength of the Doppler-shifted Fraunhofer sodium absorption lines in the solar spectrum in the atoms' frame of reference.

We discuss the implications our results for our understanding of near-Sun comets' composition and origins.

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