THE HELIOS SPACECRAFT ZODIACAL LIGHT PHOTOMETERS USED FOR COMET OBSERVATIONS AND VIEWS OF THE COMET WEST BOW SHOCK

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Abstract. The HELIOS A and B zodiacal light photometers can be used to view comets as they pass the spacecraft. Because the HELIOS spacecraft orbit the Sun on their own, and are generally far from Earth, the spacecraft allow us to view comets from a different perspective than normally available. Comet West (1976VI) passed through perihelion on February 25, 1976. The comet crossed the HELIOS A and B spacecraft zodiacal light photometer fields of view, allowing them to record the brightness, polarization and color of the comet. Data from the U, B and V photometers showed a distinct blueing followed by a slight reddening corresponding to the ion and dust tails, respectively, entering the field of view of each photometer sector. The extent of the tail of Comet West was far greater seen from the HELIOS spacecraft than seen from Earth, even taking into account their generally closer viewing perspective. As Comet West traveled away from the Sun, it was observed in the zodiacal light photometer fields of view at a solar distance of more than 1.4 AU. The zodiacal light photometers also viewed Comet Meier (1978Xx1). Comet Meier is far more compact than Comet West, extremely blue and unlike Comet West showed no significant dust tail.

The interplanetary medium is observed to a level of the variations in the brightness of the electron-scattering component near Comet West. A brightness "bump" present in the data before the comet reached some photometer positions can be shown to approximately form a parabolic shape sunward and ahead of the orbital motion of the Comet West nucleus. We presume that this bump is evidence of the position of the cometary atmosphere or an enhancement of the ambient interplanetary medium ahead of the comet motion. The brightness bump in terms of density generally corresponds to a density enhancement of the ambient medium by a few times in the vicinity of the comet. When compared with Comet Halley and couched in terms of the shock stand-off distance, the distance of this brightness increase from the nucleus implies a neutral gas production rate of approximately 2.5 times that of Halley. This is in agreement with the neutral gas production rate measured from Comet West using more direct techniques.

1. Introduction

The HELIOS spacecraft zodiacal light photometers (Leinert et al., 1975; 1981), originally intended to measure zodiacal light dust, were extremely good in that respect (Leinert et al., 1978). In addition, Richter et al. (1982), and more recently, Jackson and Leinert (1985) and Jackson (1985) have utilized these photometers to remotely observe mass ejections and other concentrations of electrons in the heliosphere. Here, we want to explore the brightness of dust and the variations of the heliospheric brightness near comets. Operating with a time cadence of 5.2 hours in any given photometer, polarizer, or UBV color, the photometers gave precise but limited spatial coverage of an entire hemisphere surrounding the spacecraft. Three photometers were directed towards 16°, 31° and 90° ecliptic

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latitudes. Brightnesses from the 16° and 31° photometers were binned into 1° and 2° strips respectively of 32 sectors, parallel to the ecliptic equator. The photometers were calibrated against bright stars falling within the sectors and were shown to be stable over time to within 4% in absolute intensity. HELIOS A viewed the hemisphere below the ecliptic plane with southward-pointing photometers; HELIOS B viewed to the north.

Observations of comets from space have been quite successful including those of the spacecraft encounters with Comets Giacobini-Zinner (e.g., von Rosenvinge et al., 1986) and Halley (e.g., Sagdeev et al., 1986). However, wide-angle views of comets from space are generally not available. The serendipitous HELIOS spacecraft observations of comets to low light levels using precision photometry are better than ever before able to determine the full extent of a comet in space. Because the photometers can at the same time measure the zodiacal light dust and electron content of the heliosphere, the interaction of these constituents with a comet can be more fully assessed.

Comet West entered the inner heliosphere from the south, passed perihelion on 25 February 1976 and continued on to the north. Comet West was well-viewed by Earth-based observers following its passage into the northern heliospheric hemisphere four days later on 29 February 1976. The position of the Comet West bow shock or bow compression was favorably located for photometric observation from the HELIOS spacecraft at these times as well. Few measurements of a comet bow shock or bow compression and the comet atmosphere surrounding the comet nucleus exist. Indeed, until in-situ measurements of the interplanetary medium near Comet Giacobini-Zinner and Comet Halley were available, the extent of a comet bow shock and extended atmosphere was little more than a theoretical speculation. However, from in-situ observations of Comet Giacobini-Zinner and Comet Halley an extended enhancement of density nearer the comet than the shock interface of the ambient medium plasma was shown to exist. The electron density beyond the region close to the nucleus itself was generally shown to be greatest at considerable distance from the comet nucleus.

Visible evidence of this enhanced electron density ahead of a comet should be difficult to detect from Earth-based observations. For instance, ground-based photometric observations used in attempts to observe extensive heliospheric shocks as brightness enhancements following flares have failed (Misconi, 1976). However, with the advent of space-borne coronagraphs (MacQueen et al., 1974; Koomen et al., 1975) it became possible to observe coronal mass ejections moving outward a few solar radii above the Sun. These mass ejections (which are thought to be density enhancements caused by ejected lower coronal or near solar surface material) have been followed into the heliosphere by use of the zodiacal light photometers on board the HELIOS spacecraft (e.g., Richter et al., 1982). Jackson and Leinert (1985) and Jackson (1985) have utilized these photometers to remotely image mass ejections and other heliospheric density enhancements. More to the point, Jackson (1986) has used these same HELIOS photometers to view the