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The solar wind interaction with Comets Machholz (C/2004 Q2) and NEAT (C/2001 Q4) as revealed by amateur images.

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Abstract

Using images acquired from a global community of amateur astronomers, we investigate the interaction between solar wind flow and the plasma tail of comets Machholz and NEAT. We attribute disconnection events, kinks and other cometary tail features to the following heliospheric phenomena: coronal mass ejections [3], movement between fast and slow solar wind regimes, and heliospheric current sheet crossings.

1. Introduction

Since the 1950s, comets' plasma (type I) tails have been studied as natural probes of the interplanetary magnetic field. The appearance, structure, and orientation of a comet's plasma tail are primarily controlled by local solar wind conditions. When the observing geometry is ideal, the direction of the plasma tail can offer clues to the local temporal and spatial variations in the solar wind flow. The plasma tail is generally oriented away from the solar radial direction. Any unusual features, such as condensations, kinks, disconnection events or deviations from the true anti-solar direction can generally be directly related to changes in the localised solar wind [1] [3]. We studied amateur images of comet NEAT, from December 2003 to December 2004, and comet Machholz, between September 2004 and June 2005, and compared the aberration angle of their plasma tail with observed and modelled values of near-Earth solar wind data and other heliospheric events.

1.1 Comet C/2004 Q2 (Machholz)

A relatively bright comet (Magnitude ~+3.5), Comet Machholz proved to be a near-ideal probe of the solar wind due to a fortunate alignment with the Sun-Earth line. The perihelion of comet Machholz was within 0.2-0.3 Astronomical Units of Earth's position in January 2005. This geometry provided a unique opportunity to reliably map near-Earth solar wind conditions out to the comet. i = 38^{o}.5893; e = 0.999461; Perihelion date (T) = 24/01/2005, 21:52 UT.

1.2 Comet C/2001 Q4 (NEAT)

Comet NEAT reached perihelion in 2004 with a peak visual magnitude of >~+3. With a large inclination, comet NEAT is a good candidate to probe the boundary between the fast and slow solar wind streams. Similarly to comet Machholz, comet NEAT came within 0.3 AU of the Earth, allowing for reliable extrapolation of near-Earth solar wind data to the comet's vicinity. i = 99^{o}.64255; e = 1.0006642; Perihelion date (T) = 15/05/2004, 23:10 UT.

2. New techniques

Using our extensive catalogue of images (e.g. Figure 1), we calculate solar wind speeds using the tail aberration angle, and a more complex technique sampling several positions along the tail, similar to that employed by Buffington et al. [2].

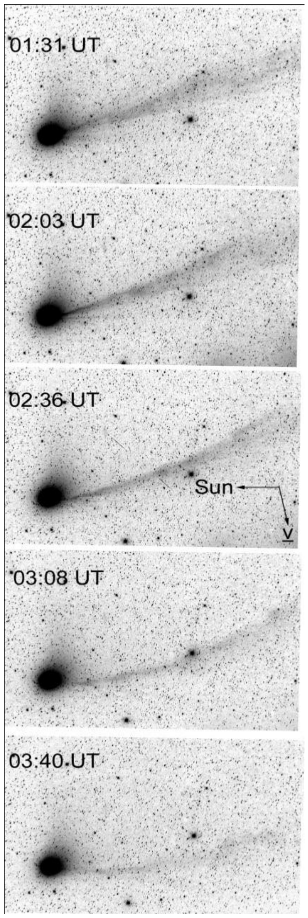

Figure 1: Images by Walter Koprolin (18/01/2005). The figure shows rapid changes in the plasma tail.

Below is list of cometary candidates used to probe the solar wind. Comet Elenin (C/2010 X1) is currently a candidate primed for observation from August 2011 onwards, assuming it brightens up near perihelion.

Table 1: Comet list

Comets	Dates of observation
C/2004 Q2	Sep 2004 – Jun 2005
C/2001 Q4	Dec 2003 – Dec 2004
C/2010 X1	TBD (Dependent on comet's brightness)

6. Summary

We have investigated the changing orientation and disturbances in the plasma (Type I) tail of comet Machholz and NEAT, to demonstrate the validity of amateur images of comets as a tool to understand the temporal and spatial variability of the solar wind in the inner heliosphere, including its speed and deviations from the nominal radial flow direction. We summarise the results of the study.

Current predictions regarding the observability of comet Elenin's plasma tail are slightly pessimistic. However, if comet Elenin displays a well-defined plasma tail around its perihelion, efforts to organise the amateur astronomer community will be undertaken. This will (hopefully) occur simultaneously with professional observations.

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