Solar-wind velocity measurements from near-Sun comets C/2011 W3 (Lovejoy), C/2011 L4 (Pan-STARRS), and C/2012 S1 (ISON)

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Since the mid-20th century, comets' plasma (type I) tails have been studied as natural probes of the solar wind [1]. Comets have induced magnetotails, formed through the draping of the heliospheric magnetic field by the velocity shear in the mass-loaded solar wind. These can be easily observed remotely as the comets' plasma tails, which generally point away from the Sun. Local solar-wind conditions directly influence the morphology and dynamics of a comet's plasma tail. During ideal observing geometries, the orientation and structure of the plasma tail can reveal large-scale and small-scale variations in the local solar-wind structure. These variations can be manifested as tail condensations, kinks, and disconnection events.

Over 50 % of observed catalogued comets are sungrazing comets [2], fragments of three different parent comets. Since 2011, two bright new comets, C/2011 W3 [3] (from hereon comet Lovejoy) and C/2012 S1 [4] (hereon comet ISON) have experienced extreme solar-wind conditions and insolation of their nucleus during their perihelion passages, approaching to within 8.3×10^5 km (1.19 solar radii) and 1.9×10^6 km (2.79 solar radii) of the solar centre. They each displayed a prominent plasma tail, proving to be exceptions amongst the observed group of sungrazing comets. These bright sungrazers provide unprecedented access to study the solar wind in the heretofore unprobed innermost region of the solar corona. The closest spacecraft in-situ sampling of the solar wind by the Helios probes reached 0.29 au. For this study, we define a sungrazing comet as one with its perihelion within the solar Roche limit (3.70 solar radii). We also extend this study to include C/2011 L4 [5] (comet Pan-STARRS), a comet with a much further perihelion distance of 0.302 au.

The technique employed in this study was first established by analysing geocentric amateur observations of comets C/2001 Q4 (NEAT) and C/2004 Q2 (Machholz) [7]. These amateur images, obtained with modern equipment and sensors, rival and sometimes arguably exceed the quality of professional images obtained only 2–3 decades ago. Multiple solar-wind velocity estimates were derived from each image and the results compared to observed and modelled near-Earth solar-wind data. Our unique analysis technique [Ramanjooloo et al., in preparation] allows us to determine the latitudinal variations of the solar wind, heliospheric current-sheet sector boundaries and the boundaries of transient features as a comet with an observable plasma tail probes the inner heliosphere.

We present solar-wind velocity measurements derived from multiple observing locations of comets Lovejoy from the 14th – 19th December 2011, comet Pan-STARRS during 11th – 16th March 2013 and comet ISON from 12th – 29th November 2013. Observations were gathered from multiple resources, from the SECCHI heliospheric imagers aboard STEREO A and B [8], the LASCO coronagraphs aboard SOHO [9], as well as ground-based amateur and professional observations coordinated by the CIOC.

Overlapping observation sessions from the three spacecraft and ground-based efforts provided the perfect opportunity to use these comets as a diagnostic tool to understand solar-wind variability close to the Sun.

We plan to compare our observations to results of suitable simulations [10] of plasma conditions in the corona and inner heliosphere during each of the comets' perihelion passage. The correlation of the solar-wind velocity distribution from different observing locations can provide clues towards the morphology and orientation of the plasma tail. We also attempt to determine the difficult-to-determine non-radial components of the measured solar-wind velocities.

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