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Water Production in Comets C/2011 L4 (PanSTARRS) and C/2012 F6 (Lemmon) with SOHO/SWAN

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Abstract

Comets C/2011 L4 (PanSTARRS) and C/2012 F6 (Lemmon) were observed throughout their 2013 apparitions with the SWAN all-sky Lyman-α camera on the Solar and Heliosphere Observatory (SOHO) satellite, which has been in a halo orbit around the L1 Earth-Sun Lagrange point since early 1996. The maximum production rates were ~1 x 10^{30} molecules s^{-1} for both comets. The activities of both comets were asymmetric about perihelion. C/2011 L4 (PanSTARRS) was more active before perihelion but C/2012 F6 (Lemmon) was more active after perihelion.

1. Introduction

The SWAN instrument is a scanning Lyman alpha imager on board the SOHO spacecraft. It consists of two identical sensors that access one ecliptic hemisphere of the sky with 5^o by 5^o field-of-view and 1^o by 1^o of resolution. During normal operations SWAN can map the entire sky in about one day. SOHO is in a halo orbit around the L1 Lagrange point about 1 million km sunward of the Earth. The main purpose of SWAN is to study the properties of the solar wind through its ionization of the neutral hydrogen wind in the interplanetary medium (IPM).

Cometary neutral atomic hydrogen comes predominantly from the photodissociation of water and the subsequent photodissociation of OH. Therefore, the analysis of SWAN observations of comets can be used to estimate their water production rates and monitor them regularly over time [1]. The placement of SOHO far from Earth and with access of the full sky precludes many of the limitations of ground-based and even low earth orbit based observations of comets, such as high air mass and bright sky twilight observations, and northern/southern hemisphere limitations.

SWAN makes routine almost-daily all-sky observations, thereby potentially observing all comets that are bright enough. These are more than adequate to determine water production rates in many comets with production rates typically larger than a few x 10^{27} s^{-1} and at heliocentric distances less than 2 to 3 AU. C/2011 L4 (PanSTARRS) and C/2012 F6 (Lemmon) were observed with SWAN beginning in December 2012. Observations of C/2012 F6 (Lemmon) continue as this paper is being written.

2. Preliminary Results

We have used the time-resolved model [2] to analyze the SWAN observations of both comets in order to calculate water production rates from each image. The fluorescence rate or g-factor is calculated from the composite solar Lyman-alpha data taken from http://lasp.colorado.edu/lisird/lya/lymanalpha.html the LASP web site and its heliocentric velocity dependence from the solar Lyman-α line profile [3] in the standard manner.

Water production rates throughout both apparitions through the end of April 2013 are shown in Figures 1 and 2. Both comets vary asymmetrically about perihelion but in the opposite sense, in that PanSTARRS was more productive before perihelion and Lemmon more productive after perihelion. Both comets also reached a maximum production rate near perihelion of close to 1 x 10^{30} molecules s^{-1}. But keep in mind that the perihelion distance of PanSTARRS was 0.3016 AU while that of Lemmon 0.7313 AU. Therefore, Lemmon was intrinsically much more active at similar heliocentric distances.

For comet C/2011 L4 (PanSTARRS) the variation with heliocentric distance is rather flat before perihelion having a power-law slope of only -1.5, but it seems to be dominated by some more irregular variation especially around 40 days before perihelion.

After perihelion the power-law slope is -2.4. For C/2012 F6 (Lemmon) the variation with heliocentric distance can be represented by a steeply rising power law with a slope of -3.6 before perihelion. After perihelion the slope is -2.1, however, it is more dominated by some irregular variations during the first 20 days when the production rate is relatively flat. The more extended coverage that is expected to continue to be monitored through at least May 2013 and possibly into June could influence this slope significantly.

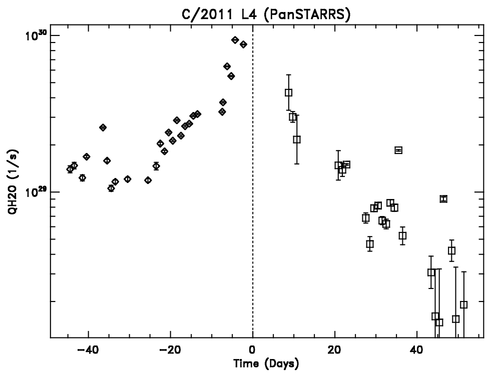

Figure 1. Preliminary water production rates in comet C/2011 L4 (PanSTARRS) as a function of time from perihelion on 2013 Mar 10.15.

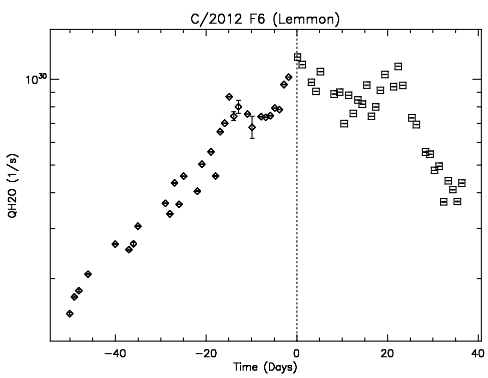

Figure 2. Preliminary water production rates in comet C/2012 F6 (Lemmon) as a function of time from perihelion on 2013 Mar 24.52.

3. Summary and Conclusions

Comets C/2011 L4 (PanSTARRS) and C/2012 F6 (Lemmon) were observed during the more active portions of their apparitions early this year. Both comets reached maximum production rates of ~1 x 10^{30} molecules s^{-1}, with that of comet C/2012 F6 (Lemmon) being reached at more than twice the heliocentric distance. An important attribute of SOHO/SWAN is that being at the Earth-Sun L1 Lagrange point we are able to get full coverage of C/2012 F6 (Lemmon) despite being a southern hemisphere object when view from Earth. Although the two comets behaved differently in their pre- to post-perihelion asymmetry, they are not atypical in that there are many other examples of very long period or Oort cloud comets that are similar to each.

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