Eclipse observations of coronal plumes in the past and in future

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Received: November 25, 1998

Abstract. Some historic fragments of eclipse investigations of polar coronal plumes are presented. New data of fundamental significance have been obtained recently thanks to the SOHO space observatory. Detection of polar plumes penetrating through the whole space of polar coronal holes is one of the most important results of the SOHO mission. It is suggested that any coronal hole independently of its location on the Sun should have structural elements like to polar plumes. The forthcoming solar eclipse of August 11, 1999 may give a favourable opportunity to detailed study of such features.

Key words: solar eclipse – solar corona – coronal plumes

1. Results

1. The polar coronal plumes have been discovered 120 years ago during the total solar eclipse of July 22, 1878. At two preceding eclipses of December 12, 1871 and April 6, 1875, coronal plumes were visible too but they did not excite any interest (see, e.g., Ranyard, 1879). In 1878, the deep minimum of solar activity took place, so the eclipse of 22nd July allowed to observe the solar corona of the 'ideal minimum type'. The appearance of the corona has impressed numerous observers including such outstanding investigators as N. Lockyer, S. Newcomb, C. Young, and others (e.g., Mitchell, 1929). Right away, the striking likeness of the polar plumes to magnetic lines of force has been noted. This gave grounds for assumption that the Sun is a huge magnet (Bigelow, 1889). Such an idea stimulated subsequent search for the general magnetic field of the Sun beginning with research by Hale (1913).

The most spectacular illustration of the 'ideal minimum type' coronal form can be found in the well-known structural drawing by Vsekhsvyatsky and Nikolsky (1955) based on eclipse observations on June 30, 1954 (Figure 1). Earlier, this picture has raised some confusion: it appeared that polar plumes therein are much too long and such an unusual length may be due to an imagination of the authors. Recent observations with the LASCO coronagraphs on the SOHO station have shown that polar plumes are very long indeed. Furthemore, eclipse photographs of plumes coincide properly with synchronous LASCO images (see, for example, a combined drawing of the corona of March 9, 1997 in Figure 2).

Contrib. Astron. Obs. Skalnaté Pleso **28**, (1999), 264 – 267.

So, we should state once again that S. Vsekhsvyatsky ang G. Nikolsky were outstanding observers of the solar corona. Let us remember some more famous investigators of coronal plumes: E. Bugoslavskaya, W. Campbell, A. Nesmyanovich, G. Newkirk, K. Saito, H. Van de Hulst, M. Waldmeier, and many others. A short review on the subject is present, say, in the paper by Koutchmy and Bocchialini (1998).

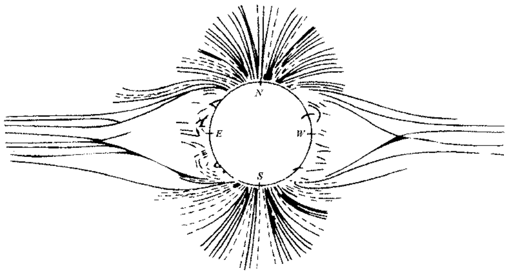

Figure 1. The solar corona of the 'ideal minimum type' of June 30, 1954: the structural drawing by Vsekhsvyatsky and Nikolsky (1955)

2. After detection of the polar plumes, the question suggested itself: how are coronal plumes distributed in the 3-D space. There were two possibilities (e.g., Waldmeier, 1956): (1) Polar plumes are distributed more or less uniformly over the whole surface of the polar cap; (2) Polar plumes are concentrated on a some circular zone, say, near the belt of high latitude prominences, and compose a kind of crown around the polar cap. According to Bugoslavskaya (1950) and Nikolsky (1956), the observed 2-D distribution of polar plumes fits better the 1st option of the 3-D distribution. On the contrary, Saito (1958) concluded that the 2nd version is valid. After discovery of the coronal holes, the 2nd option (coronal plumes border a polar coronal hole) appeared to be preferable.

The SOHO observations have settled the above issue. EUV-images of the Sun obtained with the EIT-telescope clearly indicate that polar plumes do not surround a polar coronal hole but penetrate the whole space of it similar to reinforcement bars. So, polar plumes prove to be inherent elements of the internal structure of polar coronal holes. To our mind, this is one of the most important results of the SOHO mission.

3. In so far as polar plumes are intrinsic details of polar coronal holes, they should have a genetic relationship with the high speed solar wind flowing from coronal holes. Even prior to the SOHO launch, an idea was proposed that polar plumes are just the visible manifestation of high speed fluxes, e.g., Walker et al. (1988). But most of investigators does not agree to such an idea and believes that high speed solar wind flows in the space between coronal plumes, e.g., Wang et al. (1997).

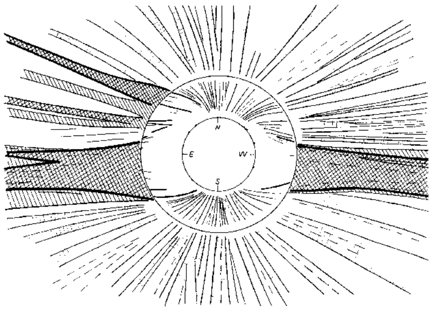

Figure 2. Combined structural drawing of the solar corona of March 9, 1997 according to Gulyaev (1998). The inner part of the pattern refers to eclipse observations; the outer region is drawn according to data from the LASCO C2-coronagraph

Let us express some considerations concerning the features called 'the coronal plumes'. It is well known that not only polar coronal holes but also any other holes (say, equatorial coronal holes) are sources of the high speed solar wind. So one could expect that any coronal hole independently of its location on the Sun should have elements like to polar plumes as inherent features of the inner structure. In such a case, we should say 'coronal hole plumes' instead of 'polar coronal plumes'. Let us remind that long ago Bugoslavskaya (1950) had pointed out occurrence of rays alike polar plumes at low latitudes in quiet coronal regions between helmets. In the famous corona of July 11, 1991, rays similar to polar plumes have been observed in NW- and SE-quadrants near the magnetic poles (Gulyaev, 1994; Sýkora et al., 1998).

4. Total solar eclipses give the most favourable opportunity to detailed high-resolution study of coronal hole plumes at low latitudes. Naturally, the presence of a coronal hole near the solar limb during the eclipse is necessary condition to realize such observations. It is expected that second half of 1999 will be related to the epoch close to the sunspot cycle maximum. If so, the coronal streamer belt will be steeply inclined with respect to the solar equator. Consequently, a chance of occurrence of a low-latitude coronal hole near the limb during the eclipse of August 11, 1999 may be rather high. Such an occasion should not be omitted. Now it is urgent again to get large-scale high-resolution coronal images like to photographs made in the past by classics of eclipse observations.

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