RELATIONSHIPS AMONG FLARE IMAGES AT DIFFERENT WAVELENGTHS

(Review Paper)

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ABSTRACT. The talk reviews briefly historical development of the imaging of the Sun, and flare imaging in particular, at different wavelengths. The present state is then critically analyzed, emphasizing and demonstrating problems related to simultaneity of observed data, differences in time resolution, limitations of the imaged field of view, unequal spatial resolution, and alignment of the images. Prospects for the future are briefly sketched, including imaging in very hard X-rays and γ-rays.

1. INTRODUCTION

The title of the Workshop, "A Forward-Looking Retrospective" brings me back to the year 1948, when I first began to observe flares using an archaic spectrohelioscope. This instrument yielded images in the Hα line and made it possible to see how far from the line center the flare still remained visible. The information one got was very limited, of course: I cannot forget Gene Parker who once said that to construct a flare from its Hα image is a task which reminds him of the reconstruction of a dinosaur solely from its footprints.

A few years later we confiscated an old German military radar and built from it a radiotelescope - on metric waves so that we began to learn also what happened in the corona above a flare. Later we used three radio frequencies so that we had some sort of a dynamic spectrum. Still, without getting any images at coronal levels, the information we got on the radio waves was pretty confusing and difficult to understand.

Much more successful was our effort to build a good optical flare spectrograph (Valnicek et al., 1959) which yielded a lot of completely new information about the chromospheric flare (Švestka, 1965); but, still, we did not know quite well which component of the flare we actually analyzed in the spectrum. We pointed to the brightest point in the Hα line: did we see there a system of tiny loops, or footpoints of big loops? Was it the primary flare we observed, or just some rather insignificant chromospheric footprints of a much more powerful phenomenon in the corona, the Parker dinosaur?

2. BRIEF HISTORY OF THE SOLAR IMAGING

Fifteen years after the time when I first saw a flare in the spectrohelioscope, in 1963, AAS and NASA organized a Symposium on the Physics of Solar Flares. We can see in its Proceedings (Hess, 1963) that even at that time the only images of flares were pictures in optical lines or in the white light. Still, the first progress in imaging at other wavelengths can be seen: pencil-beam radio interferometers (built first by Christiansen et al. (1961) and Bracewell and Swarup (1961)) could map the slowly-varying component of solar radio emission; Purcell and Tousey (cf. Friedman, 1963) got spectroheliograms of the Sun in the wavelength region 200 - 350 Å; and the Friedman's group (Blake et al., 1963) succeeded in imaging the Sun in X-rays, though the image was heavily smeared by the rocket rotation.

However, it was only in June 1968 that Vaiana and Giacconi (1969) got the first image of a flare in X-rays (between 3 - 14 Å). Shortly before that, Wild and his colleagues at Culgoora began to image radio bursts on metric wavelengths. The series of images in Figure 1, e.g., from November 1968 (Wild, 1969), probably shows the same phenomenon that the SMM imaged in X-rays 12 years later, in November 1980 (Švestka et al., 1982): a cloud of energetic electrons trapped above the flare site and staying there in a stationary position for many hours after another moving cloud of electrons had disappeared.

The Culgoora images of moving and stationary type IV bursts, drifting type II bursts, type III bursts and type I noise storms, combined with high-quality dynamic spectra, presented the best science in the

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Fig. 1. Left: Culgoora images of the type IV burst of 22 November 1968, at 80 MHz (after Wild, 1969). D is a stationary Type IV which was left above the active region after the moving parts A, B, C had left. Center: Giant coronal arch seen in 3.5 keV X-rays by the HXIS instrument on board the SMM at 10 UT on 6 November 1980. Right: This X-ray arch compared with Culgoora observations of the type IV burst (above) and with the following stationary type I noise storm (below) (after Švestka et al., 1982). The X-ray arch is apparently the lowest part of Wild's source D.