13. SOME ROCKET-OBSERVATIONAL EVIDENCES FOR INVISIBLE FLARES

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Bright chromospheric flares are sometimes not accompanied by the outbursts of radio-emission of the Sun, S.I.D.'s and increases of intensity of cosmic rays; at the same time some faint flares can be followed sometimes by these remarkable events [1]. It is natural to consider all these events, including the chromospheric emission, as different manifestations of one process in which the creation of relativistic electrons plays the chief part [2].

From this point of view, we can expect that this process can proceed in certain cases in such a way that there is no emission in the chromosphere in the region where the other events take place. These events may be called 'invisible flares'. Recently we examined the solar observational data for the first nine months of 1956 [3]. Twenty new 'invisible flares' were discovered.

Direct observations have been made of the intensity of Lα and X-ray radiation from the Sun during these flares [4].

Our point of view [2] as to the cause of the ionospheric disturbances (X-rays instead of Lα) is confirmed.

A suggestion that this radiation arises in the regions of the corona overheated at the time of flares [4] faces serious difficulties [5]. The fade-outs usually begin simultaneously with the appearance of the chromospheric flares and sometimes before them. Further, because of the low density of the corona the time of relaxation in it is of the order of an hour. Therefore, if the heating of the corona was the source of the X-ray radiation there would be a considerable retardation of fade-outs. The lack of retardation rules out this explanation, and provides some evidence in favour of the suggestion that the X-ray radiation is a synchrotron radiation of relativistic electrons which arise at the time of a flare [2].

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14. FLARE ENERGY FROM MAGNETIC FIELDS

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It is important to realize that, although the dissipation of energy in flares takes place at the expense of the magnetic field, there can be no appreciable destruction of the magnetic component generated by electric currents below the photosphere. Only the component generated by currents in the chromosphere and corona can be thus destroyed.

The question therefore arises as to how electric currents can be generated in the solar atmosphere. Atmospheric mass motions are a possible source of such currents, but it is easy to see that this particular source is neither sufficiently energetic nor sufficiently localized to explain the dissipation that takes place in flares.

We consider the main source of atmospheric electric currents to be motions that lie at the photosphere. In particular the lines of force of a filament can be twisted by rotary motions taking place at the photospheric roots of the filament. This process carries energy, via the magnetic field, into the atmosphere. With continued twisting such a filament elongates itself and becomes thinner as it stretches (a process probably observed in prominence arches).

Although this twisting process gives a satisfactory storage of energy, it does not immediately provide for the almost catastrophic discharge occurring in flares. For this, it appears necessary that two such filaments should have point contact. In the case where the longitudinal components of the magnetic field are in opposite directions, but where the rotary components are in the same sense, the penetration of the filaments at the point of contact annihilates the longitudinal components. This leaves a neutral point on the axis of the combined filaments at the contact point, and provides conditions favourable to the pinch effect. The electromagnetic forces then act in the sense of drawing the two bundles together, so that the contact point will run along the length of the filaments. A necessary condition is that the final stages of penetration occur quickly, in a time of a few seconds. It seems possible to satisfy this condition in the partially ionized gas of the lower chromosphere, provided the density is not greater than about 10^{12} atoms/cm^3.

This process can account for an explosive release of energy.

15. BURSTS OF MICROWAVE RADIO EMISSION ASSOCIATED WITH SOLAR FLARES

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The 'burst' observations at Pulkovo have been made with a polarimeter using a 4-metre diameter reflector and the large Pulkovo radio telescope with a fan-beam diagram about 1′ in width. Nine bursts have been recorded during 250 hours of observations since July 1957, seven of them being identified in time with solar flares.

The bursts are characterized by partial circular polarization, which ranges from 5 to 13%. The sign of polarization corresponds to an extraordinary mode for the dominating magnetic field in the flare region.

The emitting regions seem to be situated in the corona at 0·1–0·2 $R_\odot$ above the photosphere. No fast movements of these regions were observed. At least on 1958 March 3 the radial velocity of the burst was less than 150 km/sec. The areas of the bursts do not differ significantly from those of the flares. A brightness temperature of 10^6–10^7 °K is usual, but it can rise to 10^8 °K for some outstanding bursts.

A smooth curve of intensity is typical, with an abrupt growth and an exponential fall, the time constants of these exponents ranging from 0·3 to 15^{m}.

It is difficult to account for the observed phenomena in terms of plasma oscillations. If we assume that, in some small region of the corona, an abrupt heating takes place followed by diffusion of thermal energy, the observed intensity curve could be explained. The smooth run of the intensity curve and the sign of polarization (an extraordinary mode) are in agreement with the thermal mechanism assumption.

16. I.G.Y. SOLAR FLARE STUDIES

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Since the beginning of the I.G.Y. the U.S. Naval Research Laboratory has been conducting a programme of simultaneous observations of solar activity in both Hα and radio wavelengths of 9·4 and 3·2 cm. The analysis of the Hα and 9·4 cm. observations for the first year of the I.G.Y. indicates that 99% of the radio bursts are coincident with Hα events, and that on the average the 9·4 cm bursts of types simple 1 and simple 2 start at the beginning of the Hα flare and reach a maximum midway between the Hα flare start and the flare maximum.

The very preliminary analysis of large complex 9·4 cm bursts indicates a very close relation between the radio intensity peaks and the brightenings of different eruptive centers of the same flare.