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Abstract

Full Text

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ASTRONOMY

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Ejections in the Solar Atmosphere

(Presented by Academician V. G. Fesenkov, January 4, 1965)

In the active region of the Sun, ejections are observed both in absorption on the disk (Fig. 1) and in emission at the limb (Fig. 2). In their morphological structure they are often difficult to distinguish from a bright solar prominence,

Fig. 1. Ejection on the disk, April 2, 1960.

but they differ substantially from the latter in their spectrum and in the nature of their development. Ejections possess a high velocity of directed motion (100 km/sec and more) and a comparatively short lifetime ($(3 \div 9) \cdot 10^2$ sec). The emission line of ejections consists of characteristic "strokes" located along the dispersion ([1]).

Despite the high frequency with which the phenomena occur ([2]-[3]), observational data on the nature of their development are not numerous, and spectroscopic data are almost absent ([4], [5]).

In the present article we shall consider a characteristic ejection obtained with the AFR-2 telescope of the High-Mountain Solar Station of the Astrophysical Institute of the Academy of Sciences of the Kazakh SSR.

The general character of the development of the flare and of the limb ejection associated with it is shown in Fig. 2 (23 X 1957).

At 6 h 19 m M.T. a luminous point appeared, which expanded uniformly in all directions. At 6 h 25 m the mass began to be drawn out predominantly in one direction and, as it rose, individual jets began to be laced off.

Fig. 2. Development of the flare and emission ejection at the limb.
a –6 h 17 m 30 s; –6 h 21 m 30 s; –6 h 23 m 30 s; –6 h 25 m 30 s; –6 h 26 m 30 s; –6 h 29 m; –6 h 32 m; –6 h 36 m 30 s; –6 h 42 m 30 s; –6 h 48 m 30 s; –6 h 58 m 30 s; –7 h 05 m M.T.

The change in the height of the ejection on the image plane with time is given in Table 1.

Table 1

T, M.T.	6 h 35 m	6 h 39 m	6 h 45 m	6 h 51 m	6 h 55 m	6 h 59 m
$10^{-10}h$, cm	1.05	1.39	1.46	1.32	1.05	0.69

The rate of ascent and descent of the ejection was constant,

$$v = (h_2 - h_1)/(t_2 - t_1) = \text{const}.$$

The ejection rose at a velocity of $1.4 \cdot 10^7$ cm/sec and descended at a velocity of $1.2 \cdot 10^7$ cm/sec. The ejection reached its maximum height in $1.08 \cdot 10^3$ sec. After reaching the maximum height, the material of the ejection descended along the same path by which it had risen upward. The total lifetime of this ejection was $2.7 \cdot 10^3$ sec.

Let us estimate, for a limb ejection, the total number of hydrogen atoms. According to (^{4}), we shall assume that $n_H \sim 10^{12}$ cm^{-3}. Then the total number of atoms contained in the ejection is $N_H = 1.5 \cdot 10^{41}$, and its mass is $N_H m_H \sim 2.4 \cdot 10^{17}$ g. If one also takes into account the number of helium atoms in accordance with the cosmic abundance of the elements, $n_{\text{He}}/n_H = 0.1$, then the total mass will be $3.4 \cdot 10^{17}$ g.

Since the velocity of motion of the ejection is known, $v = 1.4 \cdot 10^7$ cm/sec, one can find the kinetic energy

$$(N_H m_H + N_{\text{He}} m_{\text{He}}) v^2/2 \simeq 10^{31} \text{ erg};$$

on the other hand, according to numerous studies, the estimate of the energy emitted during a flare in all forms is as follows: visible and short-wavelength radiation, which contains the greatest part of the energy, is of the order of 10^{29} erg; the energy of corpuscular radiation is about this value; the energy of cosmic rays is $\sim 10^{28}$ erg (10^9 eV), and the energy of radio emission is several orders of magnitude smaller, $\sim 10^{25}$ erg. These estimates refer to flares of high power.

Consequently, a small part of the kinetic energy of an ejection would be sufficient for the formation of flares with the observed characteristics.

Although the estimates given above are approximate, they show that energy obtained by some volume from outside is in one case transformed into the kinetic energy of motion—an ejection—and in another into thermal energy, which is transformed into radiation—a flare.

Which particular transformation occurs in each individual case—an ejection or a flare—is probably determined only by the general configuration of the magnetic field of a group of sunspots.

In order to have an idea of the scale of the phenomenon, it is useful to compare the mass of gases contained in ejections with the mass of the middle chromosphere, since it is generally accepted that nonstationary processes are localized in the latter.

The volume of the middle chromosphere is $V \sim 2.5 \cdot 10^{31}$ cm^3. With an average density $n \sim 10^{11}$ cm^{-3}, the total mass is $\sim 4 \cdot 10^{18}$ g. It follows from this that, in order to obtain the observed phenomenon, to provide the mass of the ejection it is necessary, in a comparatively short interval of time, to compress and eject 0.1 of the entire surface of the chromosphere. However, this contradicts observation, since the active region of the Sun within which ejections occur occupies an area much smaller, i.e. no more than 10^{-3} of the surface of the Sun.

On the other hand—if one admits the incredible—then after a dozen ejections the Sun would be left without a chromosphere. Thus, the material contained in the ejection cannot be "supplied" to it from the surrounding region. Consequently, one must think that ejections are a deep-seated formation occurring in the photosphere or in the lower chromosphere bordering on the photosphere. The same point of view was recently expressed by I. S. Gopasyuk et al. (^{3}).

It is still impossible to answer the questions: what is the depth at which ejections are embedded, whence the energy is taken, and what is the mechanism of their formation. This is a problem whose solution depends on the further accumulation

knowledge about the nature of active regions (the nature of sunspots, the behavior of plasma in a variable magnetic field, the interaction of magnetic fields, etc.).

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REFERENCES

1. I. A. Prokof' eva, *Solar Data*, No. 4, 1957.
2. K. de Jager, *Structure and Dynamics of the Solar Atmosphere*, IL, 1962.

3. I. S. Gopasyuk, M. B. Ogir' , T. T. Tsap, *Solar Data*, No. 4, 1963.

4. T. V. Kazachevskaya, A. V. Severny, *Izv. Krymsk. astrofiz. obs.*, 19 (1958).

5. V. P. Vyazanitsin, M. N. Gnevyshev et al., *A Course of Astrophysics and Stellar Astronomy*, 3, 1964.

Note: Figure translations are in progress. See original paper for figures.

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