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ALTERNATIVE FLARE ACTIVITY INDICATOR: MAD

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ABSTRACT

In the present work we introduce a new flare activity indicator, MAD and examine its characteristics by analyzing a set of successive three days' observations of a typical active region, AR2372. The computed MAD is compared with conventional activity indicator such as separator. It is found that (1) MAD traces very well the separator, (2) it singles out local discontinuity of magnetic field lines and (3) it is a good measure of describing the evolutionary status of active region.

Key Words : Sun: magnetic fields, flare

I. INTRODUCTION

Flaring phenomena are thought to be closely related to the magnetic field topology in such a way that a flare occurs at a position where discontinuity of magnetic fields exists. As magnetic topological term, separatrices are defined as a surface that separates the connectivity of field lines and a separator is their intersection. The separator is considered to be the flaring site at which current sheets are formed. In this paper we introduce a new flare activity indicator, MAD which represents local discontinuity of magnetic field configuration.

II. A PROPOSED ACTIVITY INDICATOR

By definition the magnetic field vectors near a separator should either cross or change abruptly. Therefore, the angular difference between any two adjacent field vectors near the separator is expected to be large. This makes it possible to locate the separator by singling out local maxima of the angular difference in various places in the active region.

On this basis we consider MAD, as an alternative to separator, which is defined as

$$MAD = \max\left[\frac{180}{\pi}\arccos\left(\frac{\vec{B}_o\cdot\vec{B}_i}{|\vec{B}_o||\vec{B}_i|}\right)\right], \quad (1)$$

where $\vec{B}_o$ is the magnetic field vector at a given position(x,y,z) and $\vec{B}_i$ is one of the adjacent field vectors under consideration in 3-D space. If two adjacent magnetic fields are antiparallel, MAD becomes 180°. In a similar way one can define a 2-D MAD in an observing x-y plane. In practice 2-D MAD is more useful and convenient, since it can be obtained directly from observed vector magnetogram without any *apriori* assumption of the existing field configuration with height.

III. COMPARISON WITH CONVENTIONAL INDICATORS

We considered a set of successive 3 days' magnetic observations of AR2372 (April 6 ~ 8 1980) where numerous flares were reported. This active region is made up with a main dipole and a parasitic dipole which are nearly antiparallel to each other. In order to compare MAD with the conventional indicator, first we followed Demoulin et al. (1994) to approximate the field configuration by taking a linear combination of potential fileds characterized by a set of two magnetic dipoles with different strength. Then we computed the longitudinal field distribution projected on x-y plane, MAD and separator. The resulting computed MAD, separator and magnetic neutral line for first day data are shown in Figure 1, where the dotted line in Fig. 1(b) refers to the magnetic inversion line.

As can be seen from Fig. 1(b), the computed MAD traces quite well the separator and nearly coincides with the highly sheared magnetic inversion line. Based on our analysis, the computed MAD decreases with time as AR2372 evolves, implying that the degree of magnetic complexity of the active region declined with time. This is consistent with the decrease in the magnetic shear observed along the magnetic inversion line. This demonstrates quite convincingly that MAD is capable of identifying separator and locating positions at which an abrupt change in field lines takes place. Our computed 2-D MAD is compared with X-ray observations (Canfield et al. 1993) in Fig. 2, where high contour levels in the 2-D MAD map match well with the observed X-ray bright points. All of these point to that MAD could serve as a good activity indicator, at least equally as well, as the conventional one.

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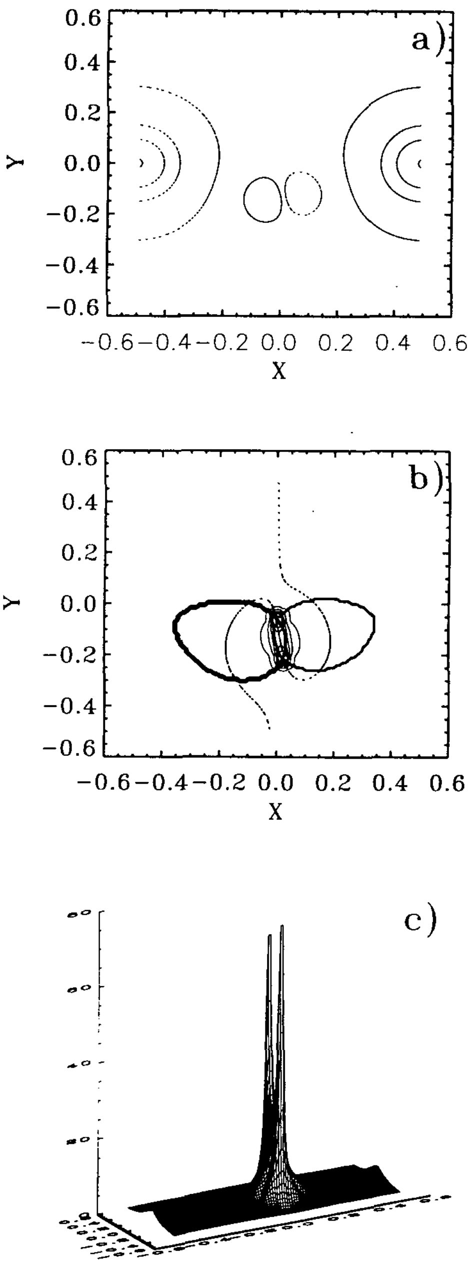

Fig. 1.— a) Computed longitudinal field distribution projected on x-y plane (generated by a main magnetic dipole accompanied by a parasitic diplole). b) Computed MAD contour, Separatrices, and inversion line. c) 3-D MAD surface contour. The contour levels in Fig.1(a) are 100,500,1000,2000 Gauss for positive (solid line) and for negative (dotted line) fields, respectively.

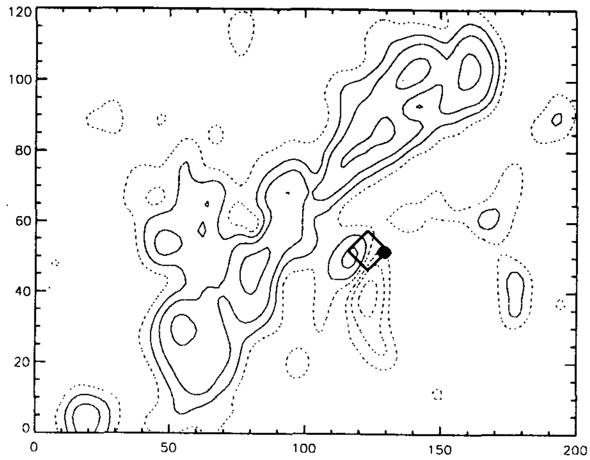

Fig. 2.— Longitudinal fields, 2-D MAD (a filled hexagon), and X-ray bright points (a thick diamond). The contour levels of longitudinal fields are 200, 500, 1000 Gauss for positive (solid line) and for negative (dotted line) fields, respectively.

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