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Movie of the Interplanetary Magnetic Field

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Movie of the IMP-1 Interplanetary Magnetic Field

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This note describes a 16 mm movie representing a portion of the IMP-1 magnetometer observations of the interplanetary magnetic field. The movie may be borrowed upon request to Dr. John M. Wilcox, Space Sciences Laboratory, University of California, Berkeley, California.

The movie represents approximately 12 days of interplanetary field observations, beginning with the second orbit of IMP-1. As shown in Figure 1, the film begins with a portion of a small sector with field toward the sun, followed by a sector boundary at which the field direction changes from predominantly toward the sun to predominantly away from the sun. This corresponds to the commencement of a recurring geomagnetic storm at 2117 UT on 2 December 1963. After the sector boundary the first day and a half of a large "away" sector is shown, and the satellite then enters the magnetosphere on day 338 at approximately 1500 UT, and observations of the interplanetary medium are not possible. The intervals during which IMP-1 was near perigee and was within the geomagnetic field have been blanked out in the present representation. On orbit 3 the satellite began observing the interplanetary medium at about 0600 UT day 339 and re-entered the magnetosphere at about 1100 UT day 342. This orbit is a continuation of the large away sector associated with the long series of recurring geomagnetic storms. This sector also contained the recurring stream of $\sim$ 1 Mev protons observed by Fan, Gloeckler and Simpson (1965). Orbit 4 displays the trailing portion of this large away sector. The satellite began observing the interplanetary medium at about 0600 day 343 and re-entered the magnetosphere at about 0800 UT day 346. Note the toward filament contained within this away sector, extending from about 2200 UT day 343 to 0330 UT day 344. Orbit number 5 shows the preceding portion of a large toward sector. The satellite began interplanetary observations at about 1000 UT day 347 and the film ends about day 350. A clock in the upper left hand corner of the picture indicates the time of observation.

The movie emphasizes in an unique way the dynamic character of the interplanetary field. Figure 2 shows the IMP-1 directional histogram for the field component parallel to the ecliptic. The distribution is clearly stretched out approximately in the direction of the indicated spiral field pattern. However, as shown by this histogram, the field at any given time may be found in any direction. In particular, the direction may be normal to the spiral angle, or even making an angle of greater than 90° to the expected spiral direction. This latter case can come about when a field that is directed, for example, away from the sun turns slowly and continuously such that for short periods of time the field may be directed toward the sun, but still rather unambiguously identified as part of an away sector. A sector boundary, on the other hand, is usually observed to occur within a few minutes or less, and thus is a very abrupt change of direction associated with a very thin boundary (a vector corotating with the sun at distance of one astronomical unit would have an azimuthal velocity of approximately 435 km/sec).

The movie was produced on an IBM 7094 computer equipped with a DD-80 data display system at the Lawrence Radiation Laboratory, Livermore. The format is shown in Figure 3. The screen represents the ecliptic, and the origin at the center of the screen can be thought of as being at the satellite or alternatively, for present purposes, at the earth. The direction to the sun is upward and the direction to the right is the orbital velocity of the earth about the sun. A dotted circle centered at the origin represents a magnitude of 5 γ (5×10^{-5} gauss). An Archimedean spiral magnetic field line would be at approximately a 45^o angle connecting the upper right hand corner and the lower left hand corner of the picture. The observed interplanetary field component parallel to the ecliptic is represented as a heavy solid line (OA in Figure 3) with one end fixed to the origin and the other end representing the magnitude and direction of the parallel component. A vertical dashed line (AB in Figure 3) attached to the free end of the solid line points up when the field component is northward and down when the field component is southward, and has a length proportional to magnitude on the scale indicated by the 5 γ circle. The abscissa and ordinate scales at the edge of the figure also yield field magnitudes in gammas when they are multiplied by ten. Each data point represents a 5.46 minute average of the original observations, and there are seven linear interpolations between each of the 5.46 minute data points. Each day's observations takes about 2 minutes on the movie so that time is compressed by a factor of about 700. It is recommended that for group viewing the film be projected at sound speed.

The interpolations for the component parallel to the ecliptic are made as follows: between two 5.46 minute vectors, a vector is constructed whose position bisects the angle between the data vectors and whose magnitude is the average of the magnitudes of the two data vectors. This process is then repeated until a total of seven interpolated vectors have been constructed. The component perpendicular to the ecliptic has seven linear interpolations.

Some of the published discussions of the interplanetary magnetic field observed by IMP-1 are included in the references.

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FIGURE LEGENDS

Fig. 1. The movie includes the time interval from 1 December 1963 to 14 December 1963, as indicated on this sector diagram. The + (away from the sun) and - (towards the sun) signs at the circumference of the figure indicate the direction of the measured interplanetary magnetic field during successive 3 hour intervals. A parenthesis around a + or - indicates a time during which the field direction has moved beyond the "allowed regions" shown in Figure 2 for a few hours in a smooth and continuous manner. The inner portion of the figure is a schematic representation of a sector structure of the interplanetary magnetic field that is suggested by these observations. The deviations about the average streaming angle that are actually present are not shown in this figure.

Fig. 2. Distribution of the measured interplanetary magnetic field direction in the plane of the ecliptic, averaged over 5.46 minute intervals. The histogram shows the field angular distribution per unit solid angle; the dashed circle would correspond to an isotropic distribution of the same number of vectors. The distribution is peaked in directions corresponding approximately to the spiral streaming angle. The angular intervals in which the field is predominantly away from the sun and predominantly toward the sun are labeled positive and negative in this figure, and represented by + and - signs in Figure 1.

Fig. 3. Format of movie. The screen represents the ecliptic plane. The origin O represents the spacecraft (or for present purposes also the earth). The direction to the sun is up, and the earth's orbital velocity is to the right. The dashed circle represents a field magnitude of 5 γ

(5 x 10^{-5} gauss). The interplanetary magnetic field component parallel to the ecliptic is shown as the heavy line OA. The end O remains fixed and the end A moves about to represent the magnitude (on the scale of the 5 γ circle) and direction of the parallel component. The field component normal to the ecliptic is shown as the vertical dashed line AB, whose length is the magnitude of this component (on the same scale). When the component is northward, B is above A, and vice versa. Thus Figure 3 represents a field component parallel to the ecliptic of magnitude 4 γ directed toward the sun almost at the spiral angle, and a normal component of magnitude 2 γ directed northward.

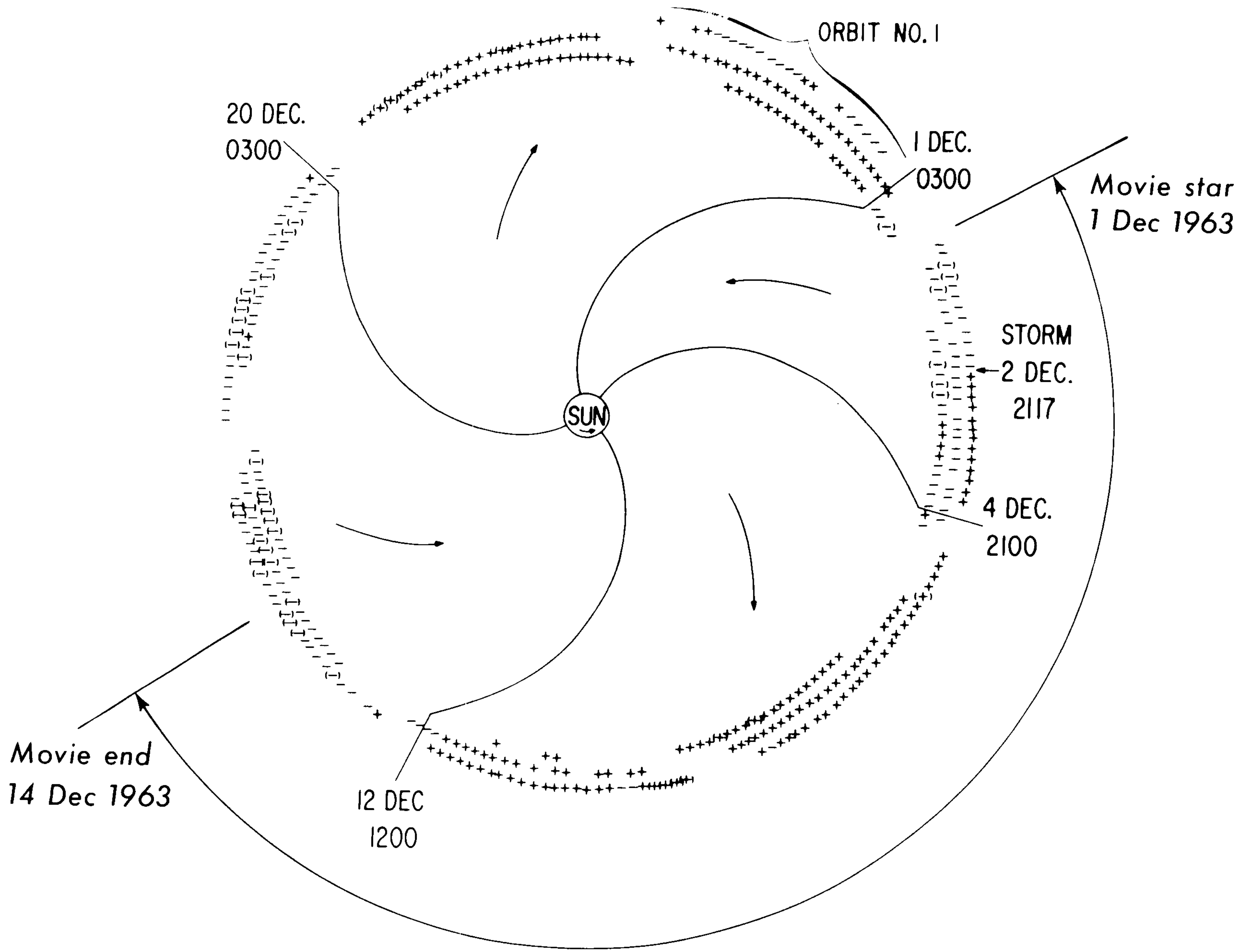
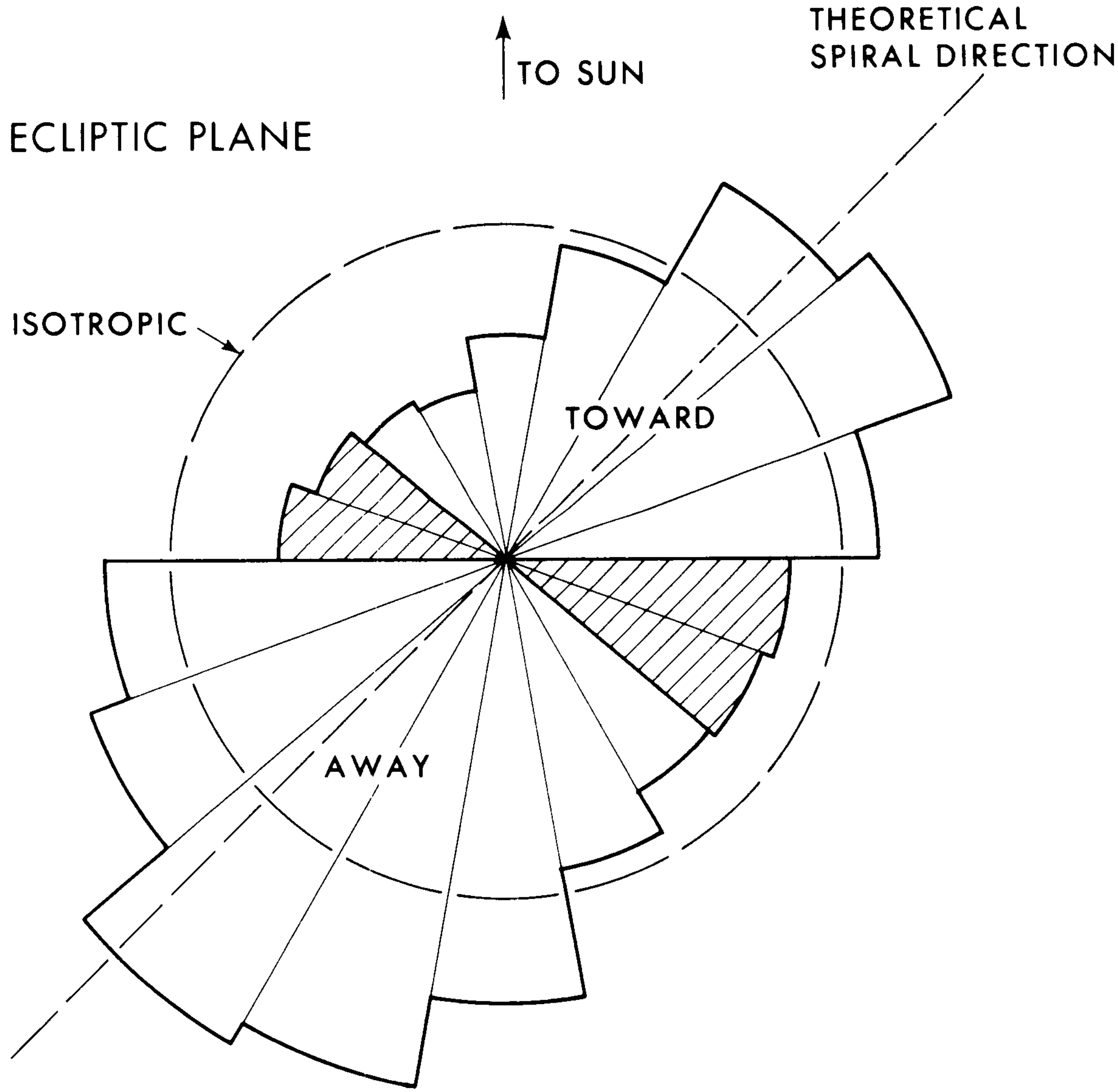

ORBIT NO. 1
1 DEC.
0300
Movie start
1 Dec 1963
STORM
2 DEC.
2117
4 DEC.
2100
SUN
12 DEC
1200
Movie end
14 Dec 1963
20 DEC.
0300

Figure 1



ECLIPTIC PLANE
TO SUN
THEORETICAL
SPIRAL DIRECTION
ISOTROPIC
TOWARD
AWAY

Figure 2

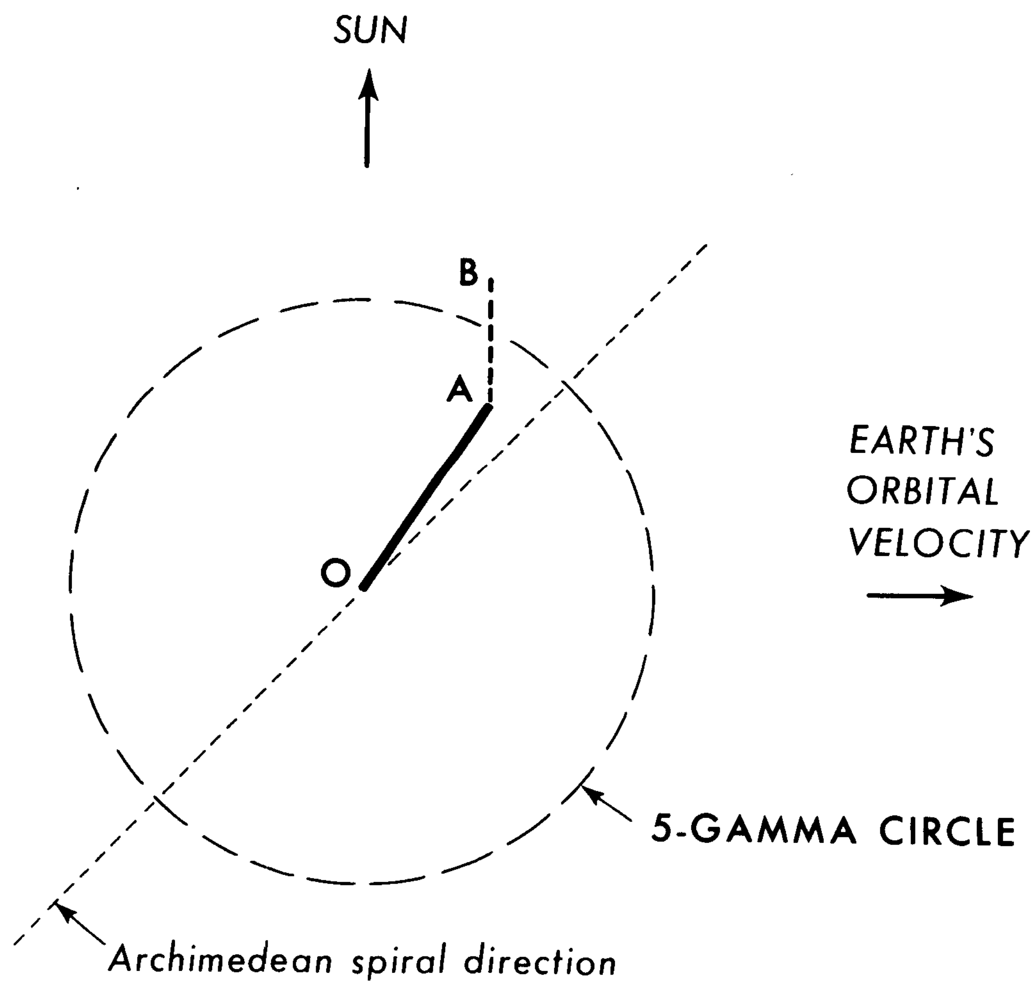

SUN
B
A
O
EARTH'S
ORBITAL
VELOCITY
5-GAMMA CIRCLE
Archimedean spiral direction

Figure 3

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13. ABSTRACT

A 16 mm movie representing the interplanetary magnetic field observed by the IMP-1 satellite during December 1 - 14, 1963 is described. The movie displays in an unique way the dynamic character of the field. It may be borrowed upon request to Dr. John M. Wilcox, Space Sciences Laboratory, University of California, Berkeley, California. (U)

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