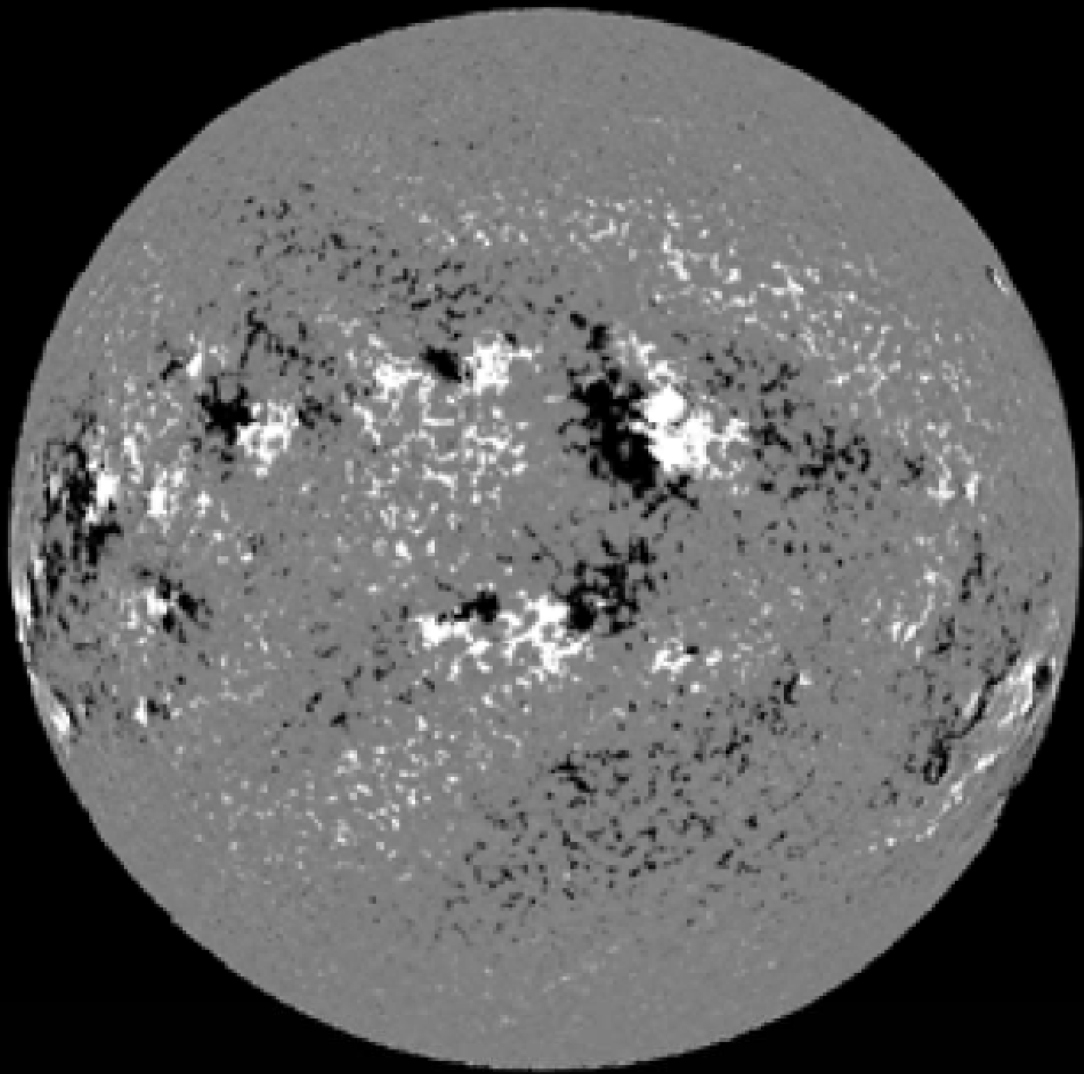
パルサー掩蔽時の RM変化による 太陽コロナ磁場3D診断

祖父江義明

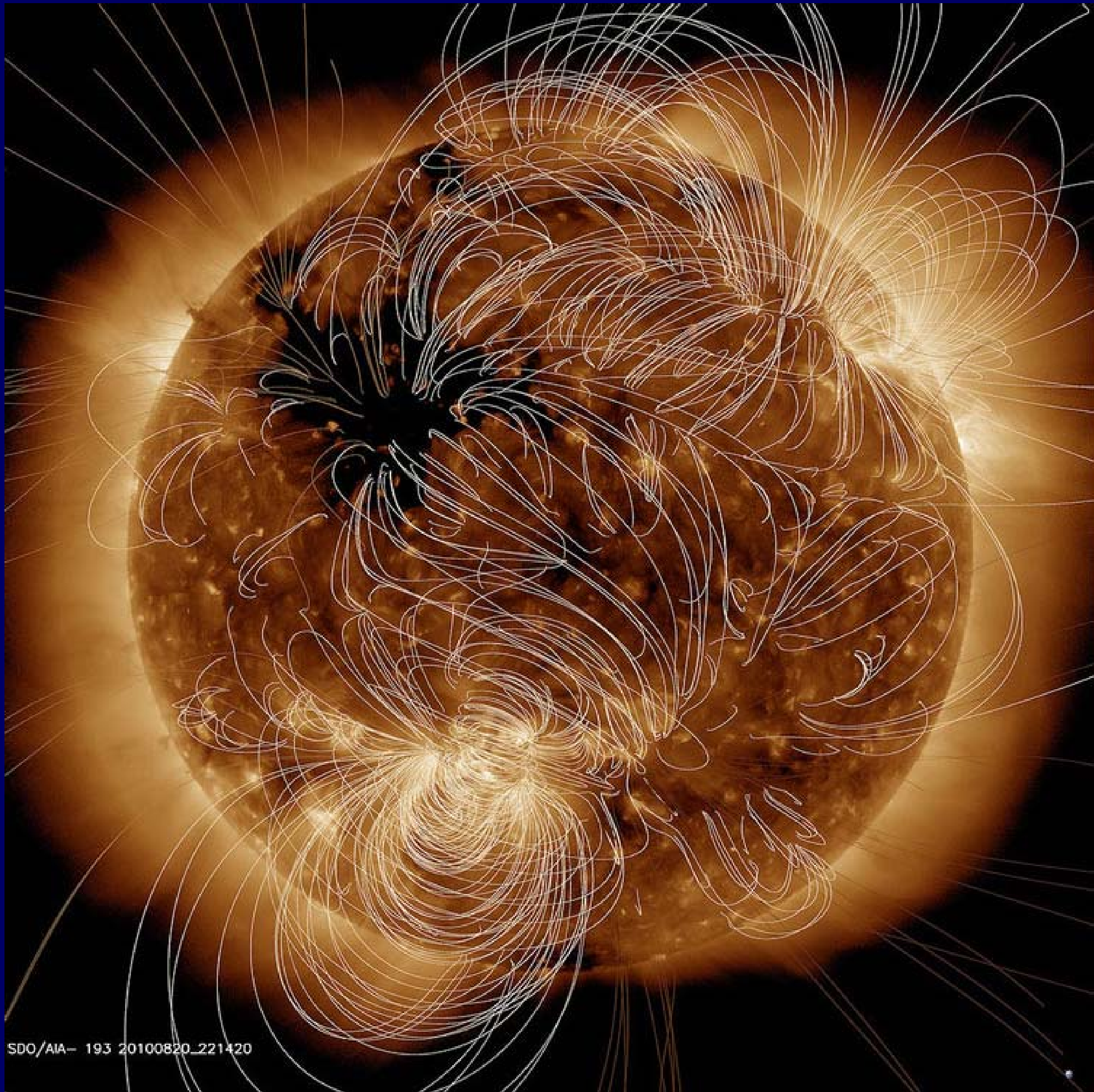
2012.6.25,26
SKA磁場会議、九州大学理

Pulsar-RM Tomography of Solar Coronal 3D Magnetic Fields

Magnetic map of the Sun
Solar maximum dominated by global dynamo



Kitt Peak magnetogram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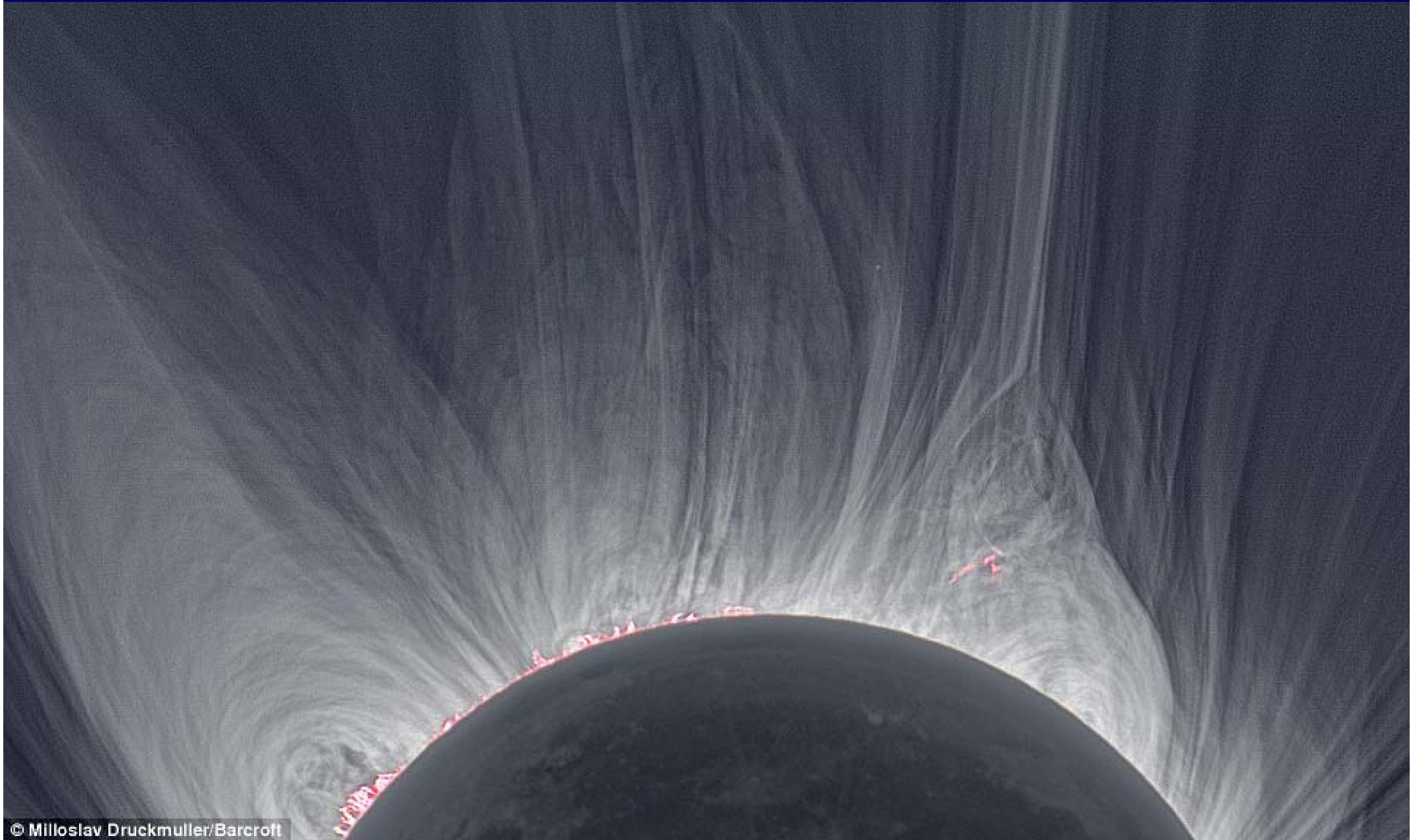
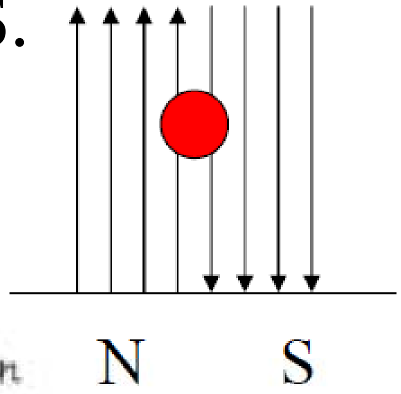
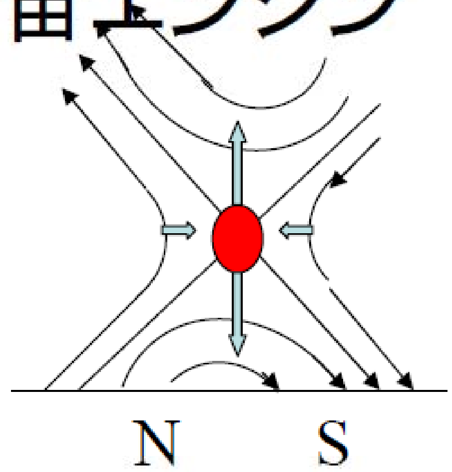


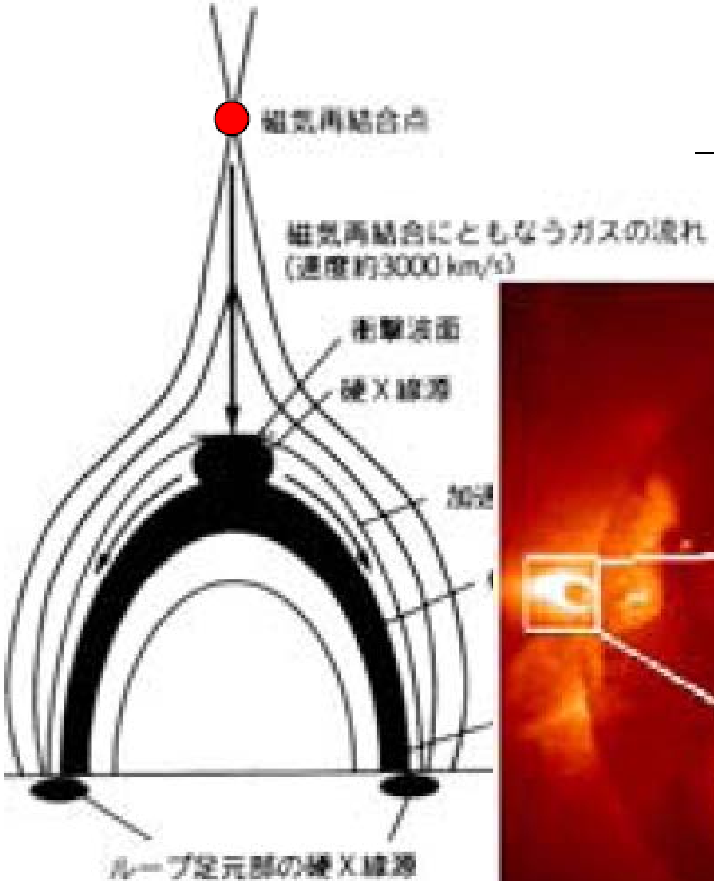
Photo: Miloslav Druckmüller

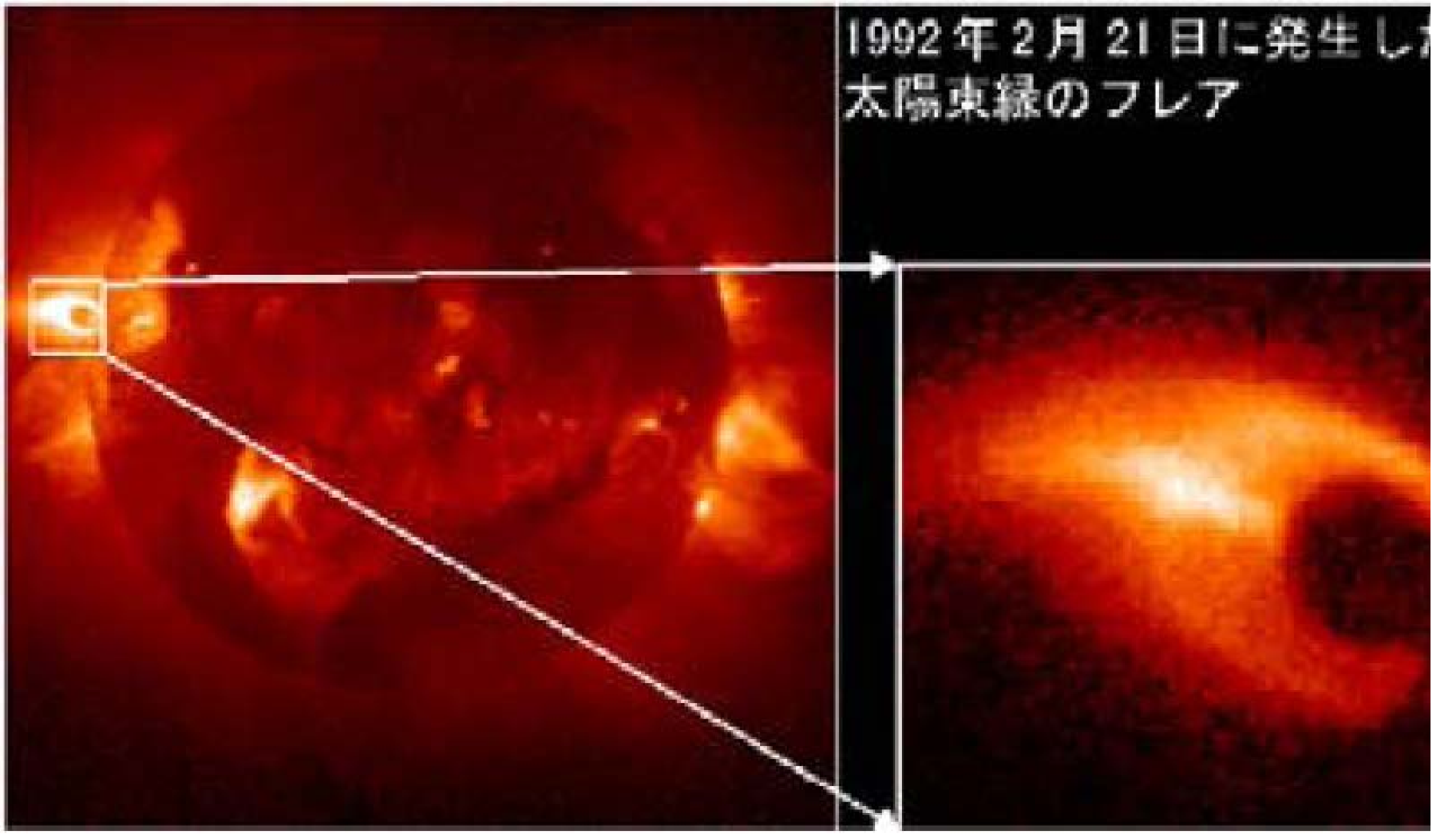
磁気リコネクション＝高効率の宇宙エンジン

Coutesey Tsuneta, S.









磁力線の向きは？
強さは何ガウス？
ニュートラルシートは？

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CORONAL FARADAY ROTATION OF THE CRAB NEBULA, 1971–1975

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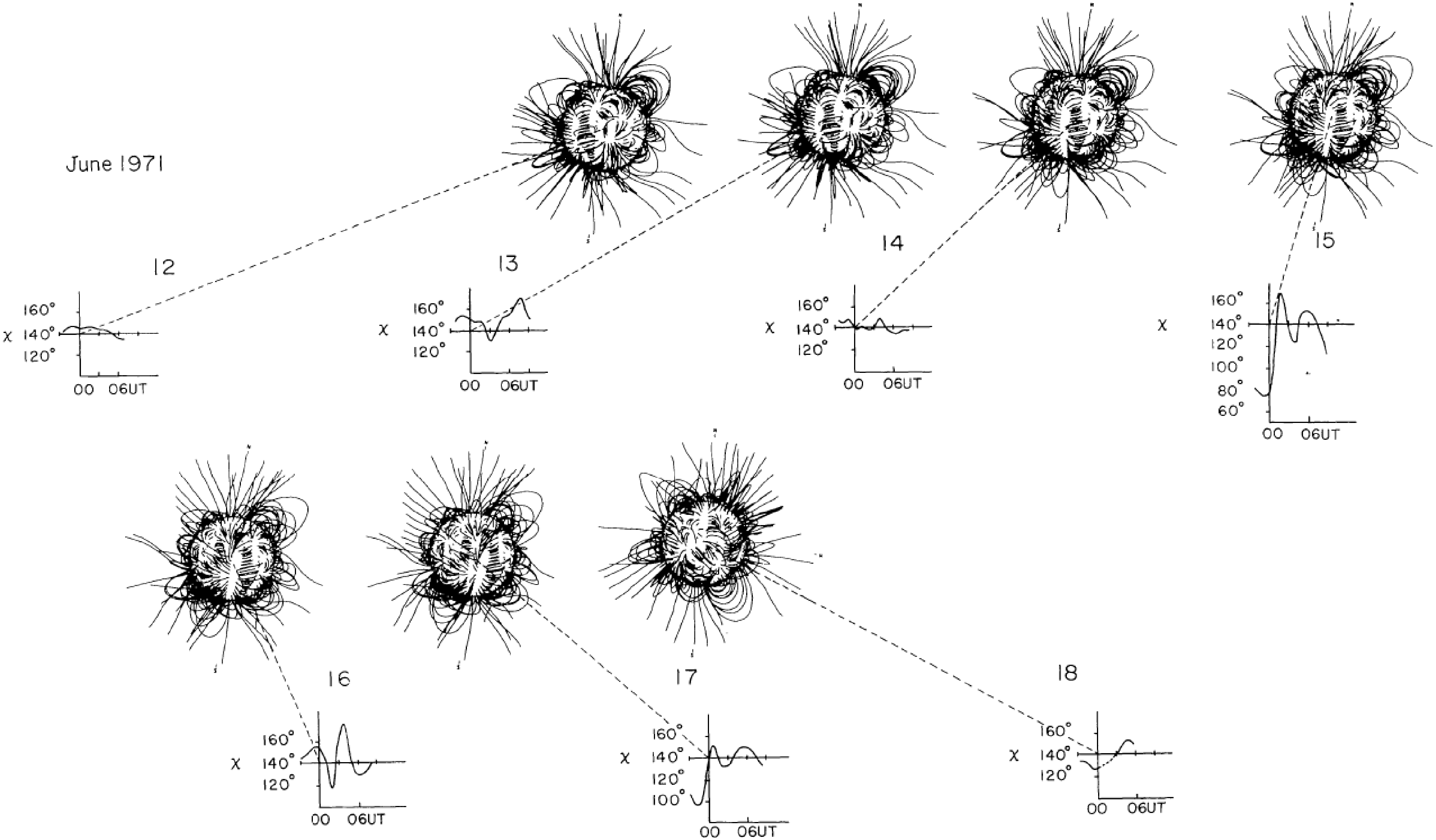
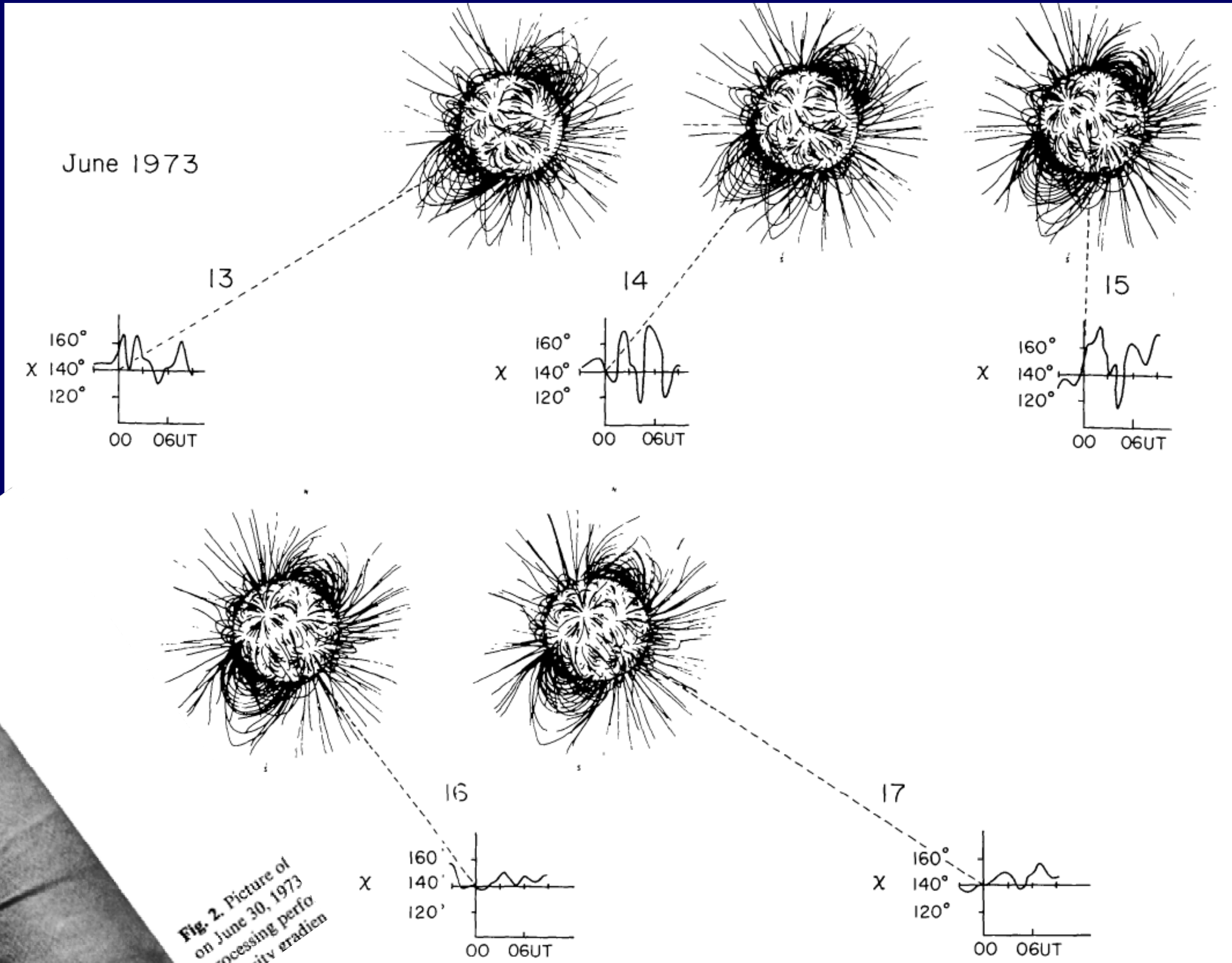
Sofue et al 1976 Sol. Phys.


June 1971
12
13
14
15
16
17
18
160°
140°
120°
100°
80°
60°
χ
00 06UT



June 1973
13
14
15
16
17
160°
140°
120°
χ
00
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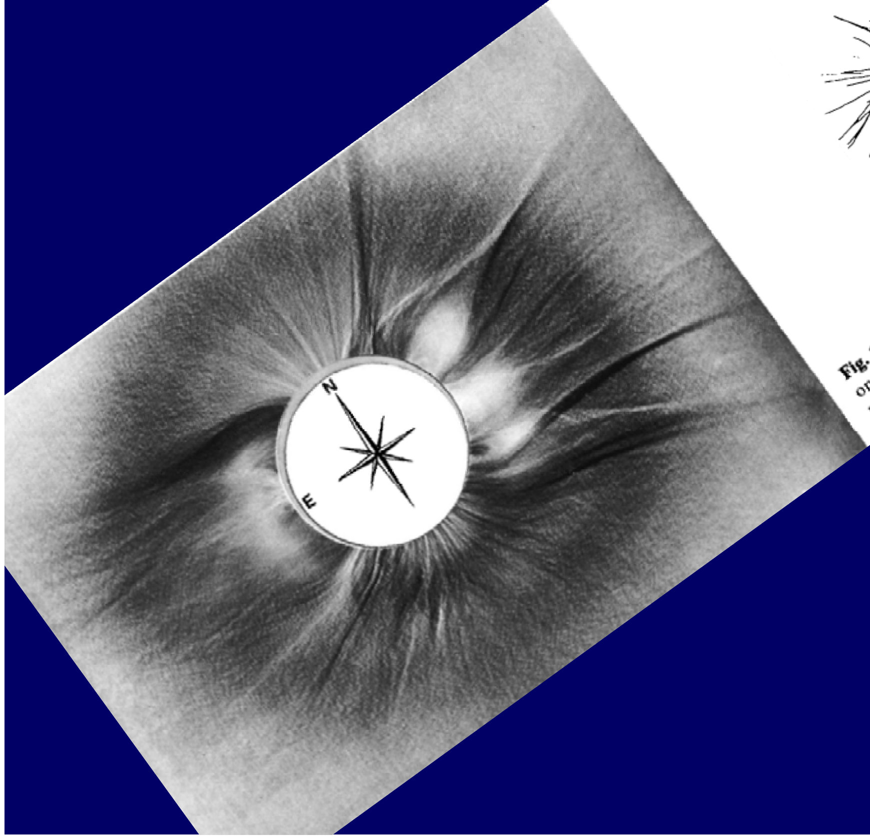
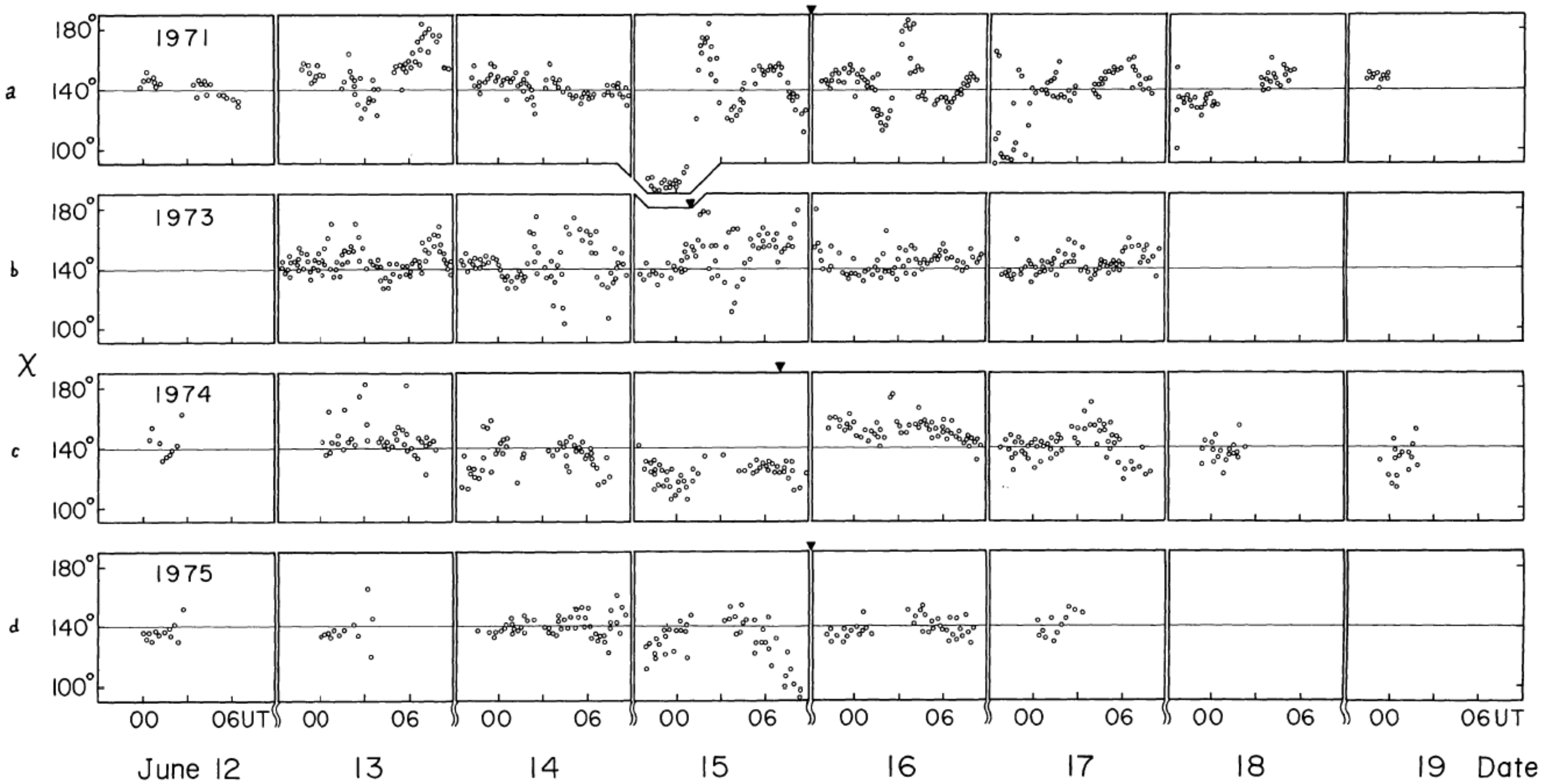


N
E
Fig. 2. Picture of
on June 30, 1973
processing perfo
intensity eradien



1971
1973
1974
1975
a
b
c
d
χ
180°
140°
100°
00
06UT
06
June 12
13
14
15
16
17
18
19
Date

degrees in the quiet phase (1974–75). The rotation angle Ω from the intrinsic polarization plane is related to the rotation measure RM and a wavelength λ as $\Omega = \lambda^2$ RM. The observed rotation angles at our wavelength ($\lambda = 7.2$ cm) corresponds to 100–160 rad m^{-2} in 1971–73, and to 30–60 rad m^{-2} in 1974–75. The rotation measure is expressed by the electron density N_e (in cm^{-3}), the line-of-sight component of magnetic fields B (in gauss), and the pass length s along the line of sight as

$$\mathrm{RM} = 1.82 \times 10^{-2} \int N_e B \, \mathrm{d}s/R_\odot \simeq 1.8 \times 10^{-2} N_e B(s/R_\odot) \text{ rad m}^{-2}.$$

If we take $s \simeq 1 \, R_\odot$ as an effective pass length across a coronal streamer, we obtain $N_e B \simeq 5600$–8100 gauss cm^{-3} in 1971–73, and $N_e B \simeq 2100$–3500 gauss cm^{-3} in 1974–75.

The electron density for a quiet corona at $R > 5 \, R_\odot$ is given by $N_e = 2.5 \times 10^6 (R/R_\odot)^{-2.5}$ (Saito, 1970), where R is the distance from the Sun. If we assume a radial magnetic field expressed by $B = 1 \times (R/R_\odot)^{-2}$ gauss, we have $N_e B = 2.5 \times 10^6 (R/R_\odot)^{-4.5}$ gauss cm^{-3}. Insertion of $R \simeq 7 \, R_\odot$ into this equation as a typical value yields $N_e B \simeq 400$ gauss cm^{-3}. In order to fit the observed value of $N_e B$ we must take both N_e and B in a coronal streamer greater than those in the surrounding coronal region by a factor of 2–4.

The observations in 1971–73 show that the polarization plane oscillates at a short period of about 3 hours. This time scale corresponds to a linear scale of 0.5 $R_\odot$ at the solar distance, if the motion of Tau A relative to the Sun is taken into account. The oscillatory variation around the intrinsic polarization plane indicates a reversal of sign of the Faraday rotation measure, and therefore a reversal of the line-of-sight component of the field direction.

Coronal Faraday Tomography using Polairzed Radio source Crab Nebula = Tau A

June Every Year.

CORONAL FARADAY ROTATION OF THE CRAB NEBULA 467

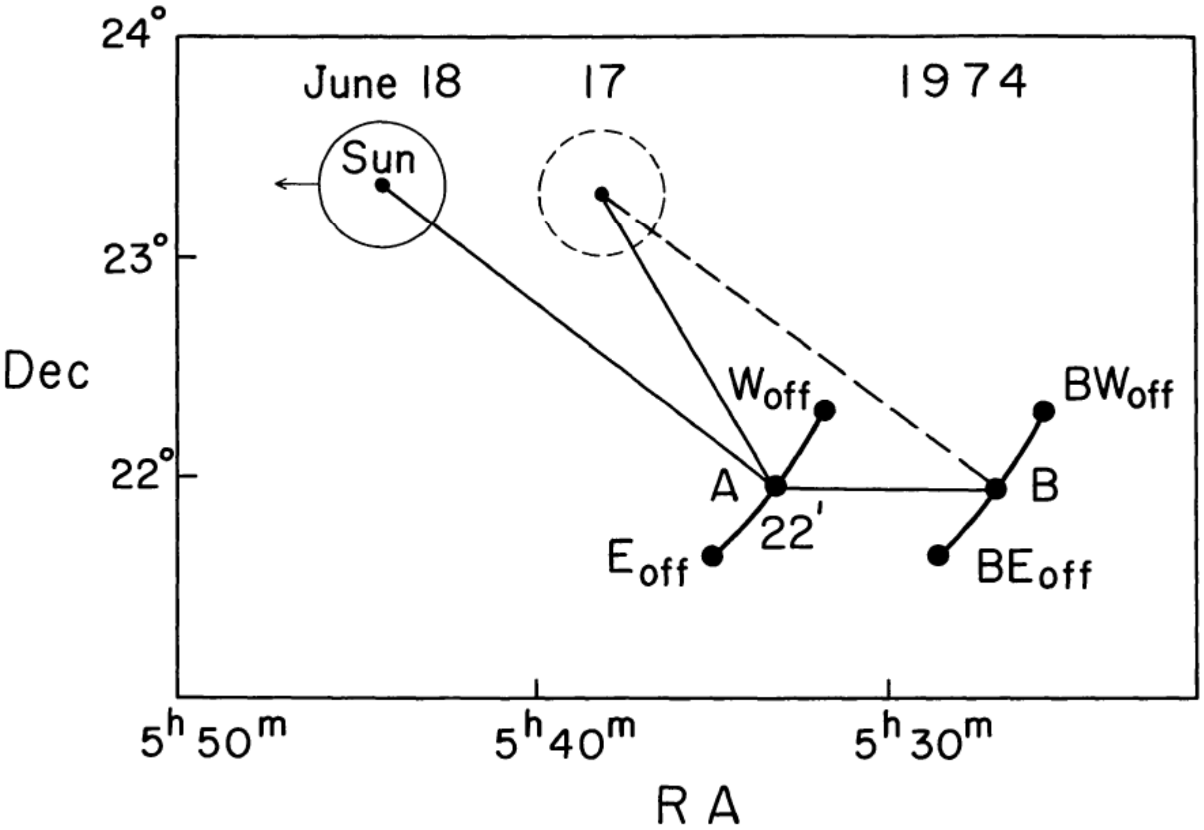
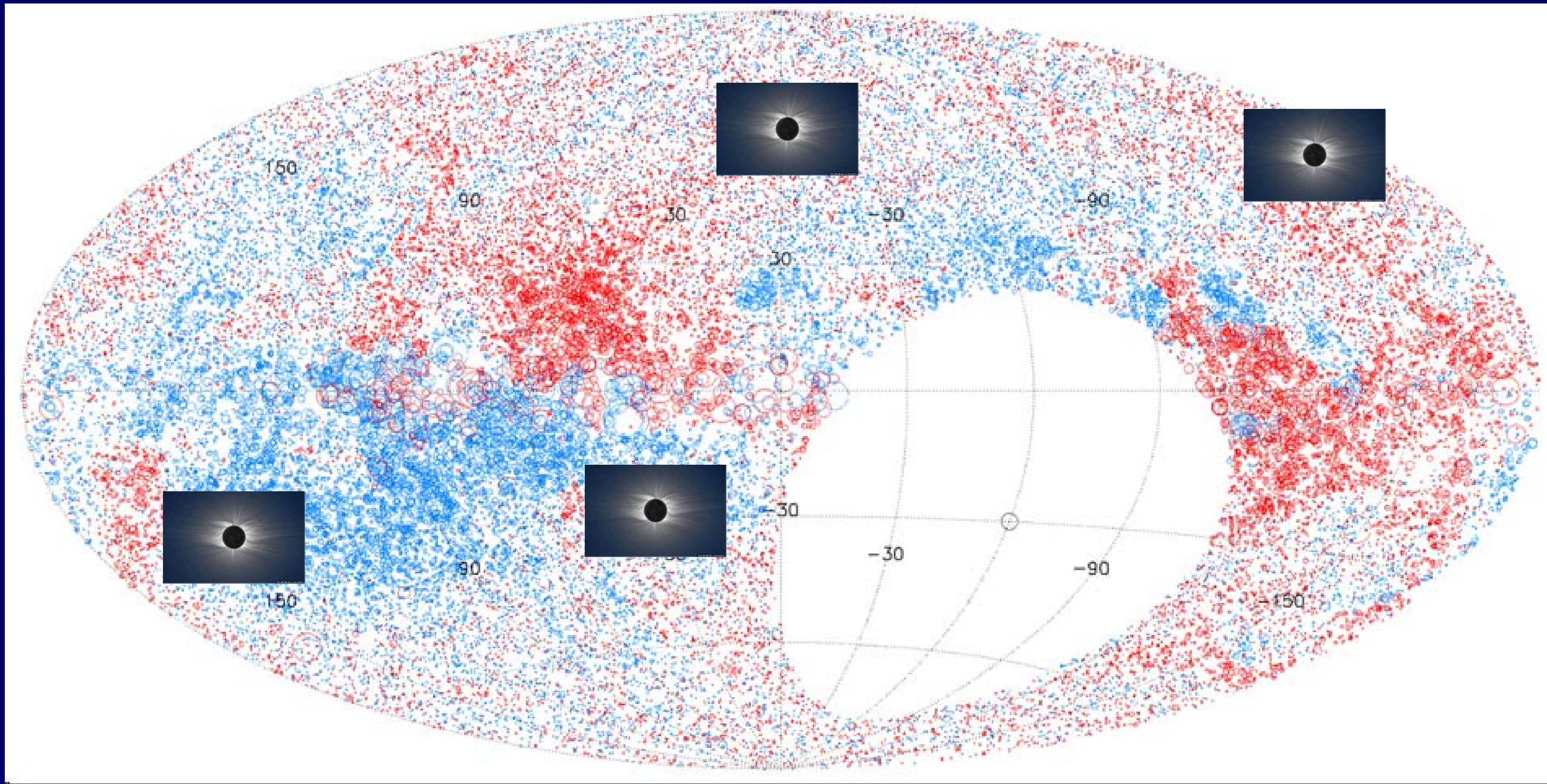


Fig. 1. Relative positions of Tau A (Point A) and the Sun on June 18 and ‘off positions’ (E_{off} and W_{off}), at

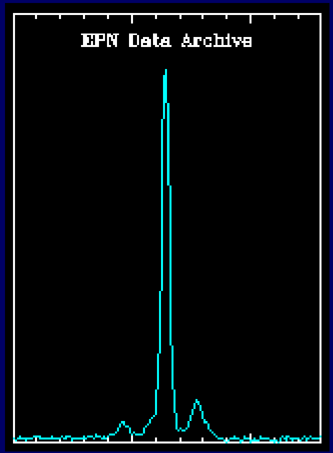
RM Sky(Taylor 2009)

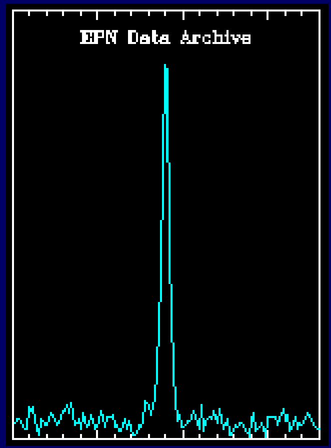


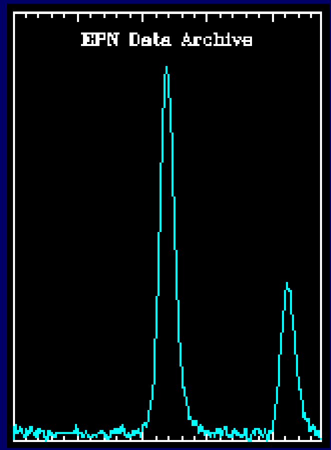
最大の困難＝サイドローブからの
太陽電波

そこで、パルサー
直線偏波による
Faraday tomography

(cf AM放送 vs FM放送)







PSR 0329+54

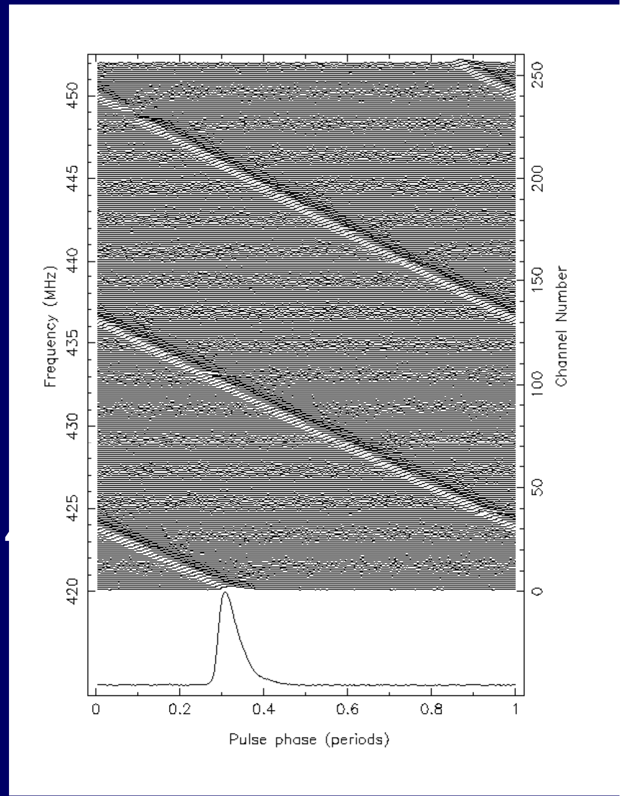
P=0.71 sec

Vela pulsar

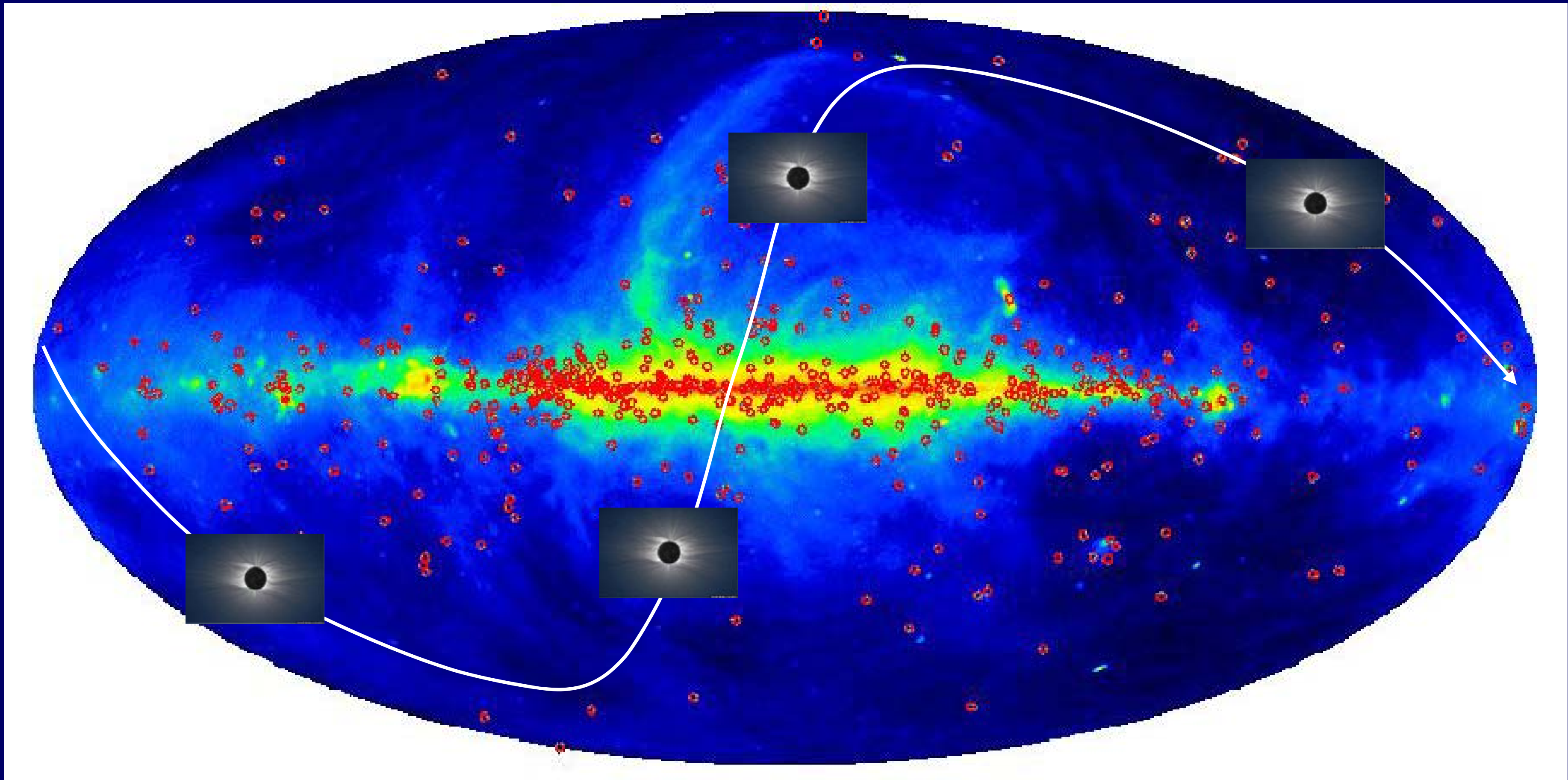
P=0.089

PSR 1937+21

P=0.00155780644
87275



Ecliptic plane & Pulsars

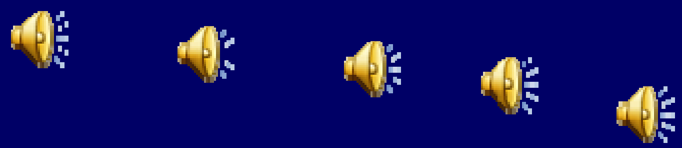


SKA:

Pulsar RM Tomography of Solar Coronal Mag. Fields.

Strongly polarised

Pulsation=>Frequency Modulation

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