THE UNIVERSITY OF WARWICK

CFSA

N-S asymmetry of the solar magnetic field from polar jets

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Coronal Hole Jets

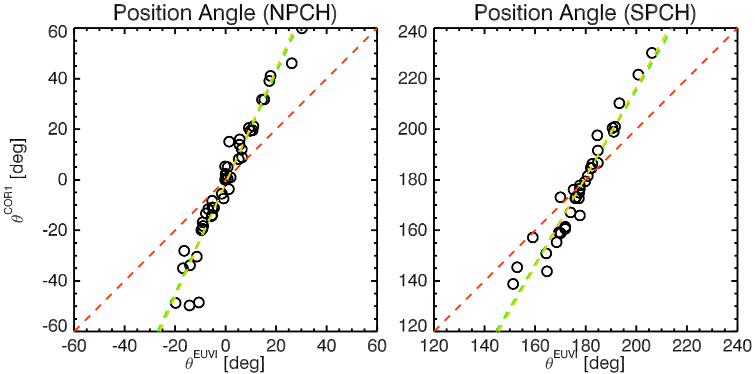
Identification of 79 jets during the period 2007–2008 in the EUVI and COR1 field of view (Nisticò et al. 2009, 2011).

Investigation of the jet motion

We determined the position angle (PA) for the 79 polar jets measured in the EUVI FOV (1 $R_\odot$) and the corresponding position in the COR1 FOV (2 $R_\odot$) (Nisticò et al. 2015).

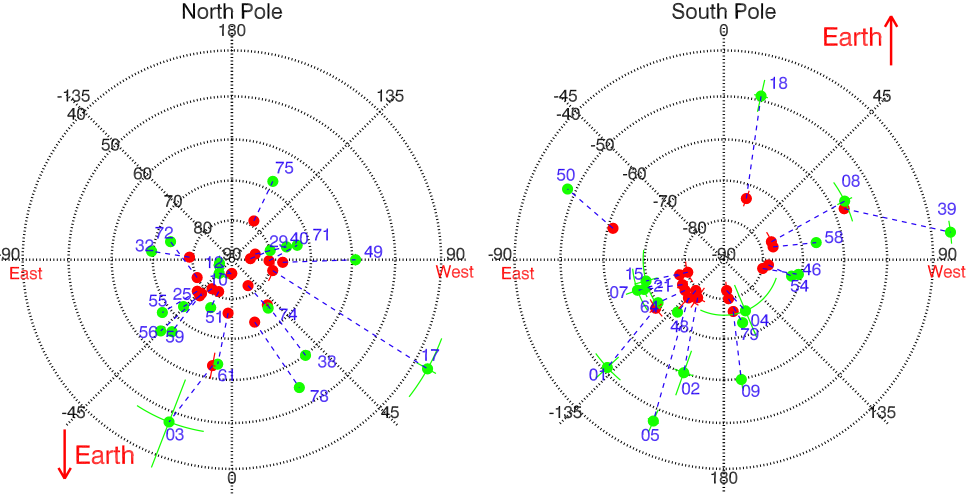
Linear fit at the North and South Pole

$$\theta^{COR1} = a\theta^{EUVI} + b$$



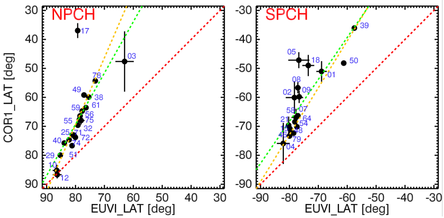
	a_N	a_S	$(a_N - a_S)/a_S$	$(a_N/a_S)^2$
PA				
LINFIT	2.18 ± 0.09	1.72 ± 0.09	27%	1.60 ± 0.21
LINFITEX	2.25 ± 0.04	1.78 ± 0.04	26%	1.61 ± 0.09

3D position analysis

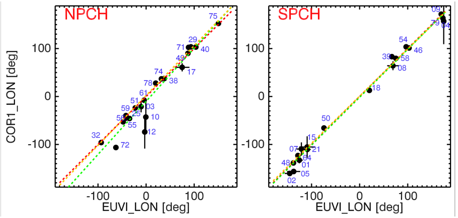


Fitting of latitudes and longitudes

Latitudes



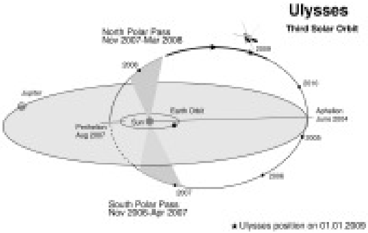
Longitudes



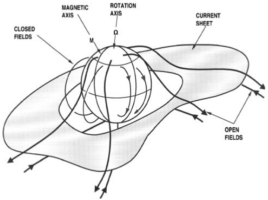
	a_N	a_S	$(a_N - a_S)/a_S$	$(a_N/a_S)^2$
Latitude				
LINFIT	1.77 ± 0.36	1.45 ± 0.24	22%	1.49 ± 0.78
LINFITEX	2.31 ± 0.06	1.62 ± 0.04	43%	2.04 ± 0.15
Longitude				
LINFIT	1.11 ± 0.07	1.00 ± 0.02	-	-
LINFITEX	1.04 ± 0.01	0.98 ± 0.01	-	-

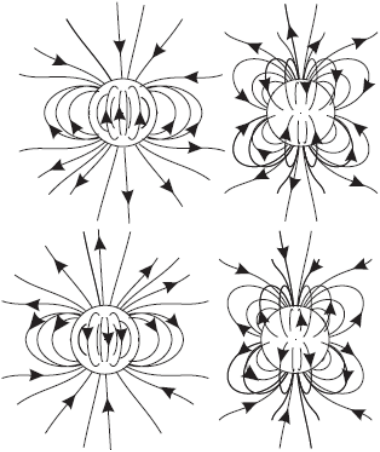
Indication of North-South Asymmetry

- sunspot area, field strength (Hoekesema, 1995), latitudinal gradients of energetic particle fluxes (Simpson et al. 1996, Heber et al. 1996)
- magnetic field measurements by Ulysses (Erdos&Balogh, 1998, 2010)



	B_S (nT)	B_N (nT)
Cycle 22	3.41	3.05
Cycle 23	2.61	2.16
	B_S/B_N	Offset (deg)
Cycle 22	1.12	3.249
Cycle 23	1.21	5.459





N-S asymmetry can be due to a quadrupole component in the magnetic field (Bravo-Esparza et al. 2000, Mursula&Hiltula, 2004)

Questions:

- How much is the quadrupole moment ?
- What is the corresponding southward shift of the H. C. S. ?

Multipole expansion of the solar magnetic field

Current free approximation→ Potential field (Altschuler & Newkirk 1969)

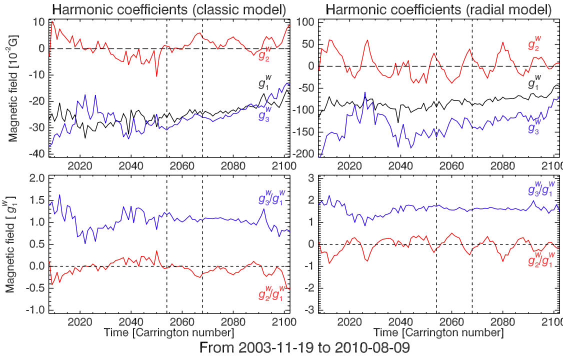
$$\Phi(r,\theta,\phi) = R_\odot \sum_{l=1}^{N} \sum_{m=0}^{l} f_l(r) P_l^m(\cos\theta)\left(g_l^m \cos(m\phi) + h_l^m \sin(m\phi)\right)$$

$$f_l(r) = \frac{\left(\frac{r_w}{r}\right)^{l+1} - \left(\frac{r_w}{r}\right)^{l}}{\left(\frac{r_w}{R_\odot}\right)^{l+1} - \left(\frac{r_w}{R_\odot}\right)^{l}}$$

Magnetic field components:

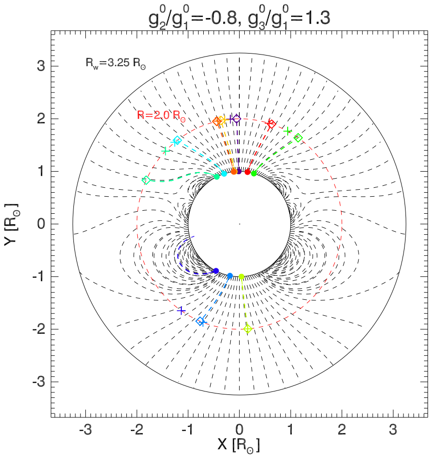
$$B_r(r,\theta,\phi) = -\frac{\partial\Phi}{\partial r} \qquad B_\theta(r,\theta,\phi) = -\frac{1}{r}\frac{\partial\Phi}{\partial\theta} \qquad B_\phi(r,\theta,\phi) = -\frac{1}{r\sin\theta}\frac{\partial\Phi}{\partial\phi}$$

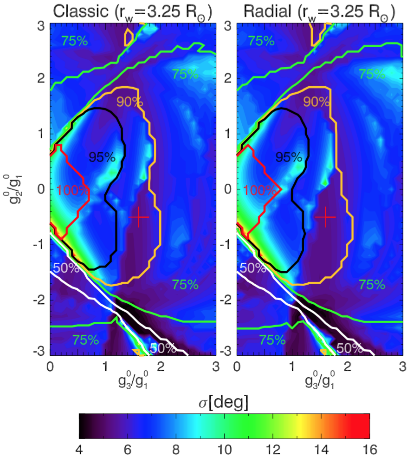
Simplified model We restricted to the case $m = 0$ → axisymmetric magnetic field. We considered $l = 1, 2, 3$, respectively the dipole, quadrupole and esapole moment.



$$\sigma(\hat{g}_2, \hat{g}_3) = \sqrt{\frac{\sum_{n=1}^{N} \left[\theta_n^{COR1\,Mod}(\hat{g}_2, \hat{g}_3) - \theta_n^{COR1\,Obs}\right]^2}{N-1}}$$

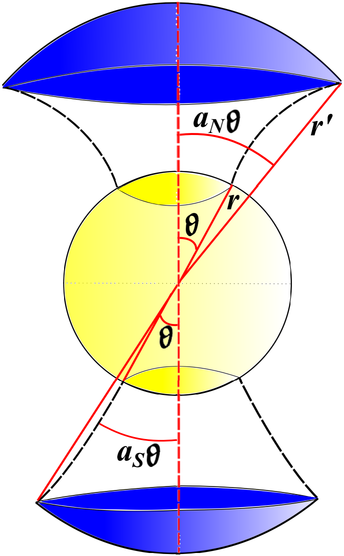
Standard deviation maps





Magnetic field structure

Polar magnetic fluxes



$$\Phi_N(\mathbf{B}) = \Phi_S(\mathbf{B})$$

$$A_N < B_N >= A_S < B_S >$$

$$\frac{B_S}{B_N} = \frac{A_N}{A_S}$$

Area for a spherical cap

$$\begin{aligned} A &= 2\pi r'^2 (1 - \cos(a\theta)) \\ \cos(a\theta) &\approx 1 - 1/2(a\theta)^2 \\ A &\approx \pi r'^2 (a\theta)^2 \end{aligned}$$

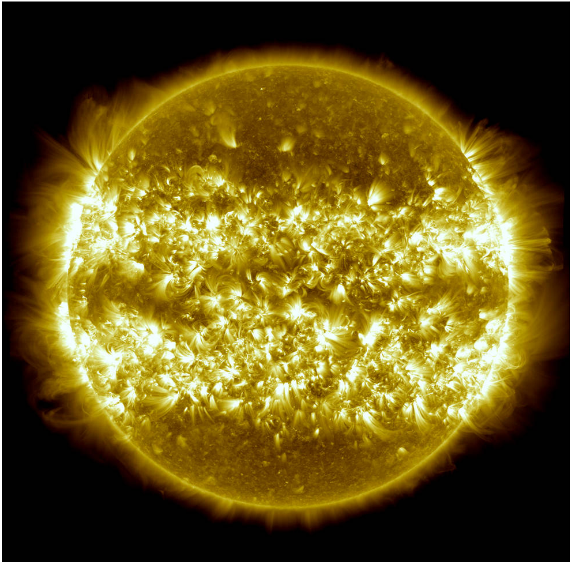
$$\frac{< B_S >}{< B_N >} = \left(\frac{a_N}{a_S}\right)^2$$

N-S asymmetry estimates

$B_S/B_N \sim 1.50 - 2.0$

Another proxy ...

www.nasa.gov/mission_pages/sdo/news/first-light-3rd.html



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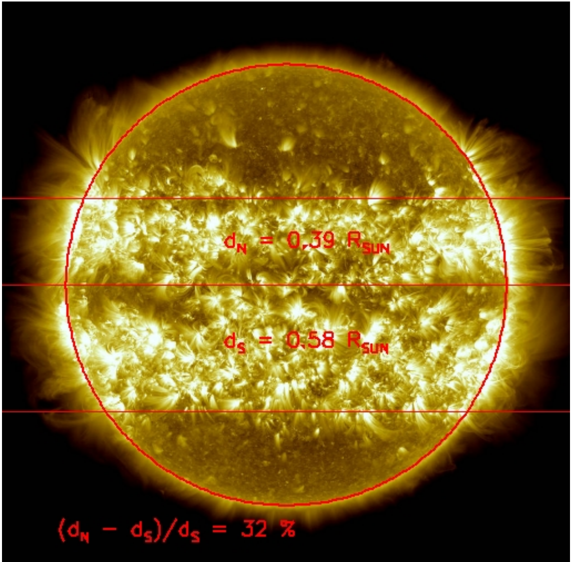

Summary

- Analysis of the variation in the position angle (PA) for jets in the EUVI (1 $R_\odot$) and COR1 (2 $R_\odot$);
- systematic displacements of jets to low latitudes; this magnetic deflection is different for the North and South pole;
- The PA variation is an indipendent indication of solar magnetic field asymmetry
- Values of $g_2^0 = -0.5 g_1^0$ and $g_3^0 = 1.6 g_1^0$ create an asymmetric solar magnetic field with a southward shift of the current sheet at the source surface of 10 deg, and the value of $B_S/B_N \sim (1.50, 2.00)$ is close to that estimated from Erdos & Balogh 2010.

Thanks for your attention!