# Spin-period model in eclipse using FGM data

MAX-PLANCK-GESELLSCHAFT

*E. Georgescu, U. Auster, F. Plaschke, K-H Fornacon, H. Frey*

Max-Planck-Institut für Sonnensystemforschung

## Introduction

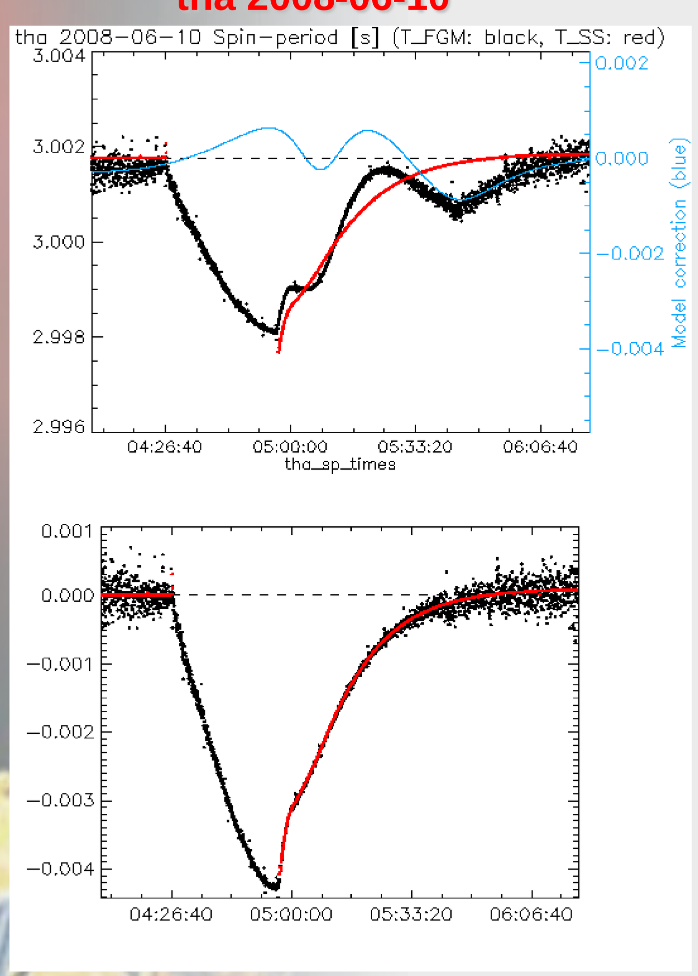
- Satellites investigating the Earth magnetosphere are mostly spin-stabilized and use sun sensors for attitude determination
- In the shadow of the Earth or Moon, the sun-pulse is missing such that vector quantities cannot be determined experimentally.
- The spin period of the spacecraft is not constant in the eclipse because the moment of inertia changes with the temperature.

**The temperature dependence of the moment of inertia has for each spacecraft a specific signature determined by its design.**

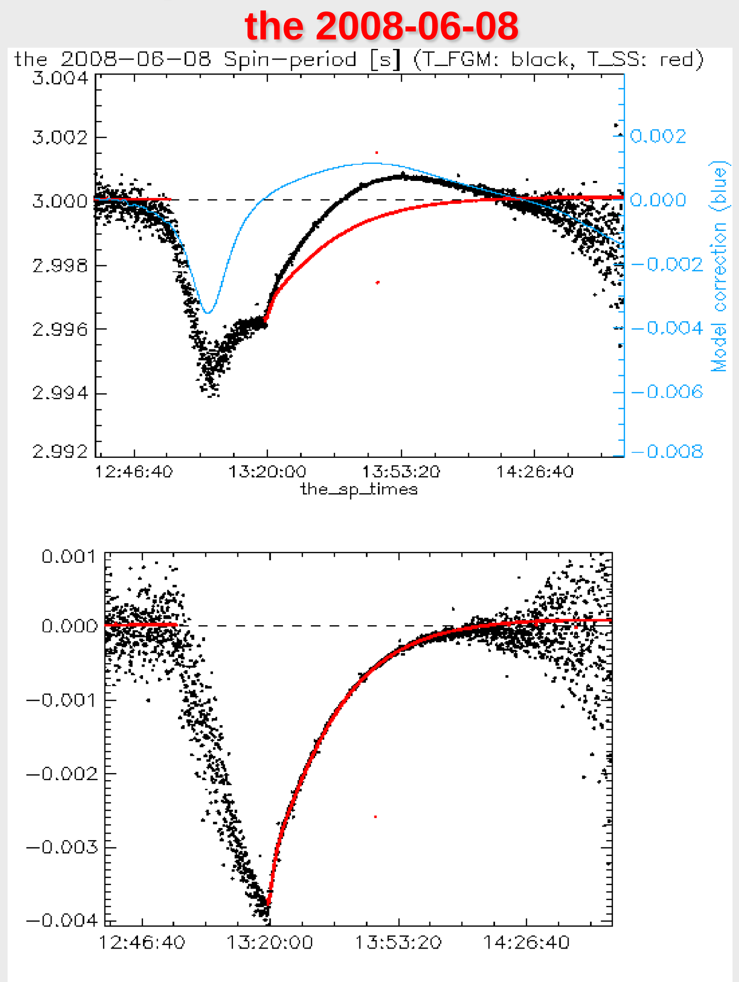
**The "eclipse-spin" model elaborated by us describes this signature by using magnetic field vector measurements in regions where the direction of the field is well described by the Earth magnetic field models or is quasi-constant.**

### Example of spin behaviour in eclipse for THEMIS

tha 2008-06-10



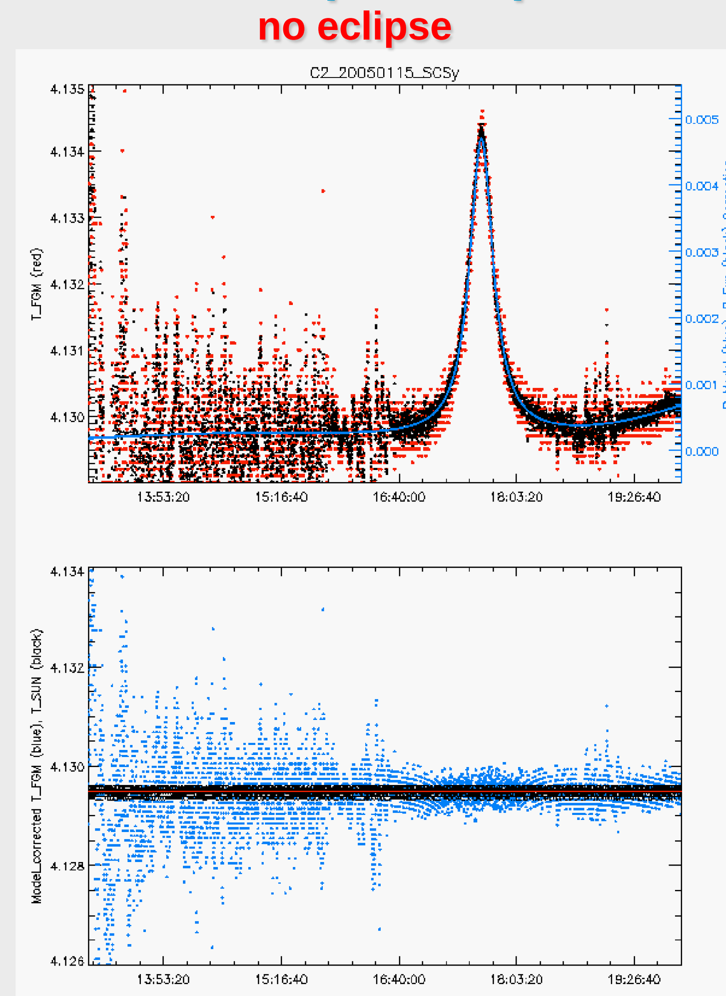
the 2008-06-08



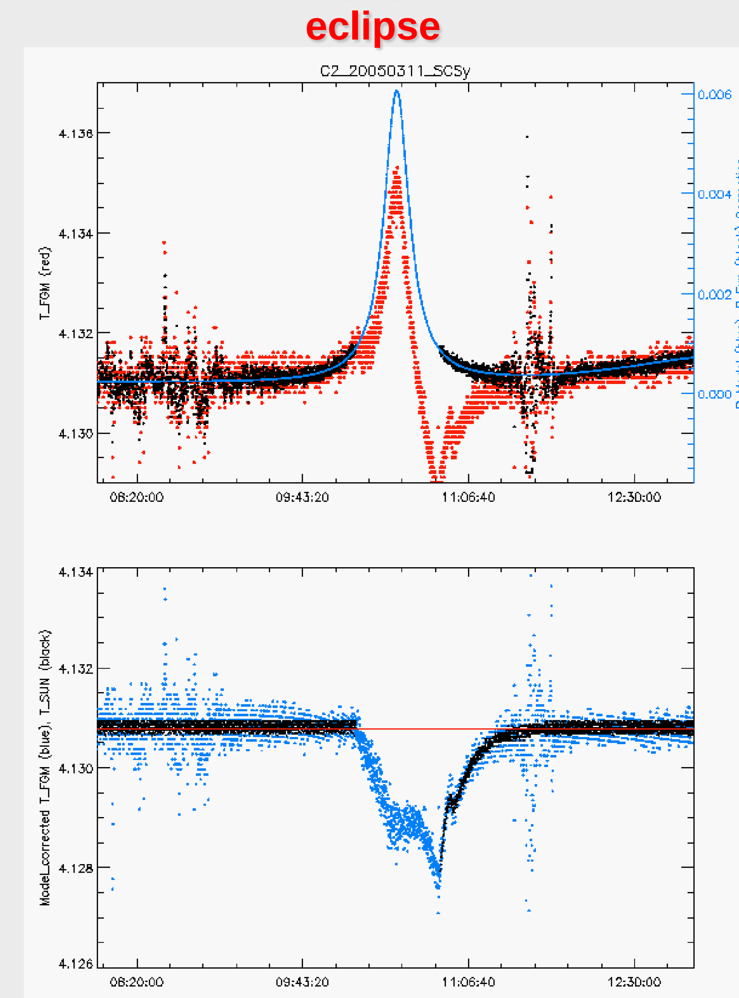
Bottom panel: T_SS (red) & corrected T_FGM (black) using field model

### Example of spin behaviour for CLUSTER

no eclipse



eclipse



Bottom panel: T_SS (black) & corrected T_FGM (blue) using field model

## Procedure to reconstitute the spin period in eclipse

**a. Build eclipse database:**

- find eclipses in T_SS: spin period from Sun Sensor
- get T_FGM: spin period from a spin plane component of the magnetic field in a rotating spacecraft frame (Cluster: FSR, Themis: SSL) determined by fitting a sine function to every spin
- correct with model magnetic field B_model: model magnetic field in a non-rotating spacecraft frame (Cluster: SCS, Themis: DSL) from IGRF + Tysganenko'96; uses position from state file; the correction function is the time derivative of the clock-angle in the spin-plane:

*Clocka = atan(B_model_y_DSL / B_model_x_DSL)*

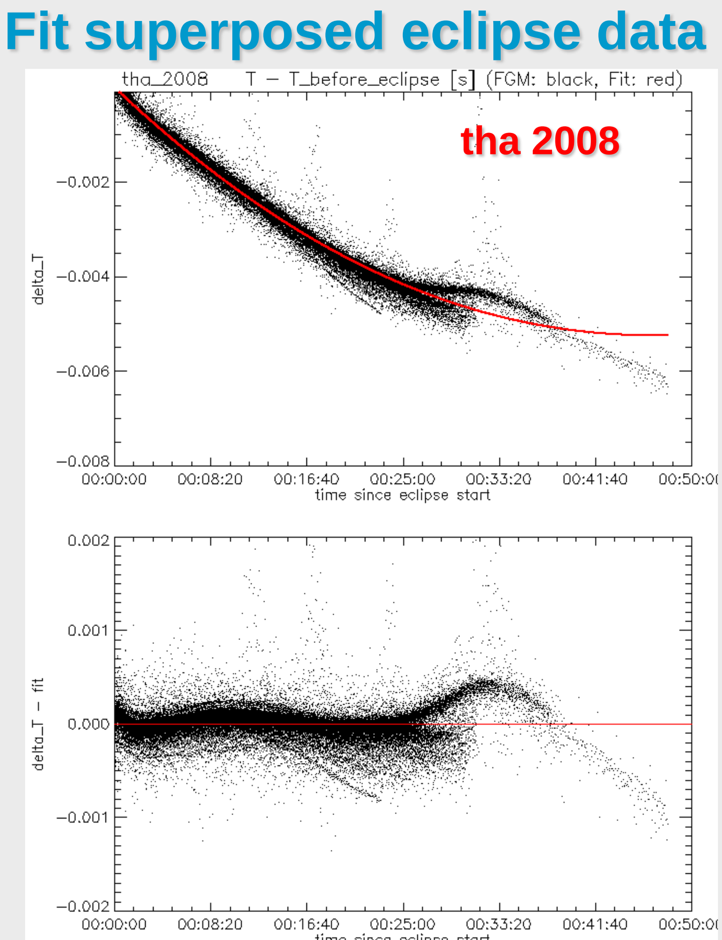
**b. Superpose eclipse data and fit (ES model = *Fitfunct*)**

*Fitfunct = a[0]*exp(a[1]*t)+t*(a[2]*t+a[3]*t)*

**c. Check eclipse-spin (ES) model with single eclipse**

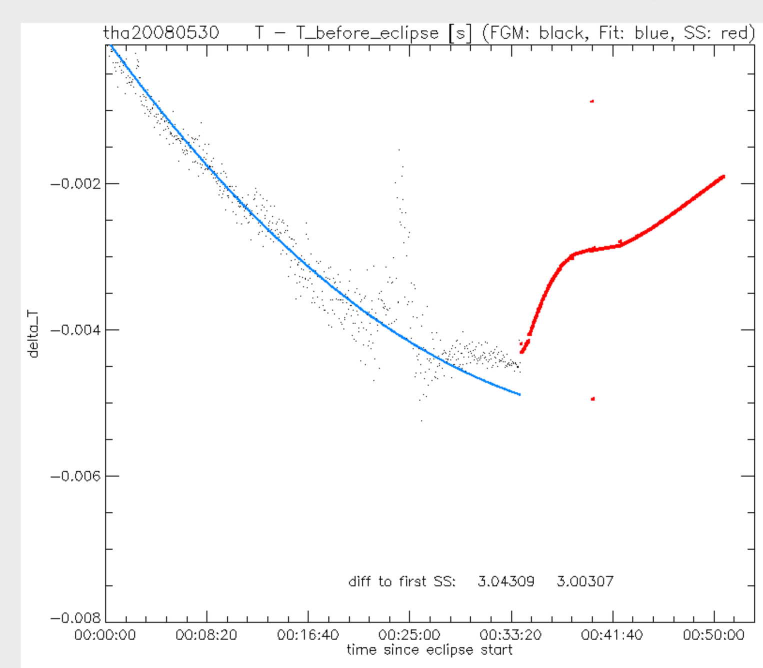
**The fit to the superposed epoch data describes well the short eclipses.** Eclipses close to perigee where the model magnetic field is well defined are „short".

### Fig b.
### Fit superposed eclipse data




**Corrected T_FGM (black)** for 2008
Fit **(red) = ESM**

### Fig c.
### Check ES model with eclipse



**T_SS (red) & ESM (blue) & corrected T_FGM (black) for 20080530**
Difference between last model spin period and the first T_SS after eclipse !

**Discrepancy when the eclipse is longer than 25 min !**

**d. Extend Eclipse-Spin model for long eclipses**

Long eclipses in quasi-constant magnetic field are required to extend the eclipse-spin model obtained by fitting the super-posed epoch data

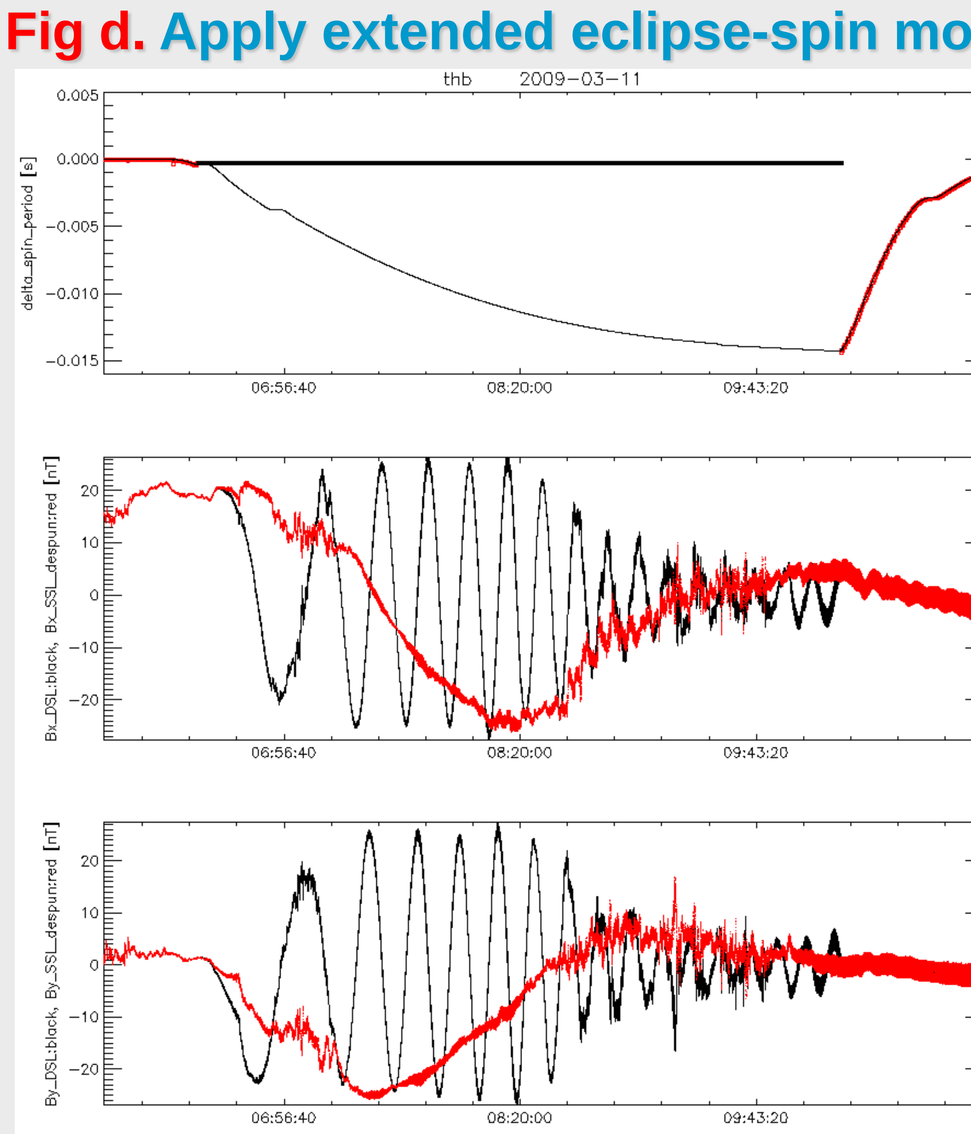
The "extended" part is fitted with a similar function as the "short" one.

The ESM is obtained by joining the two fit-functions:
- the "short" one obtained fitting the superposed epoch data for one year
- the "long" one obtained by using data from one day, where the magnetic field was quasi-constant

**No magnetic field needed after ESM is obtained**

**Fig d** shows an application of the extended ESM (thin black line) to another "long" eclipse. The magnetic field components in the spin-plane in a despun coordinate system are shown in the lower panels; Despinning with a constant period adds up to a phase error of 16 times 360° !

### Fig d. Apply extended eclipse-spin model thb 2009-03-11



eclipse duration:
**03:47:05.250**
model eclipse duration:
**03:13:53.478**

Top panel:
red:
spin-period from T_SS outside the eclipse

black:
thin line = ES model
**thick line** = fake spin period from the SunSensor

Mid & bottom panels:
Spin-plane components of the magnetic field despun with ESM (red) and with the „fake" constant period (black)

## CONCLUSION

- The spacecraft spin behaviour in the eclipse is characteristic for each spacecraft and reflects the dependence of the moment of inertia on temperature
- An "eclipse-spin model" for the spacecraft spin period behaviour using magnetic field vector measurements was developed.
- The ES model compensates for the lack of experimental spin phase information from the sun sensor, such that satellite experiments, depending on correct spin phase information, can deliver science data even during eclipses.
- The application of the method to CLUSTER and THEMIS data confirm the validity of the assumption and give good results for the spin period reconstitution.