Introduction to MMS & THOR missions

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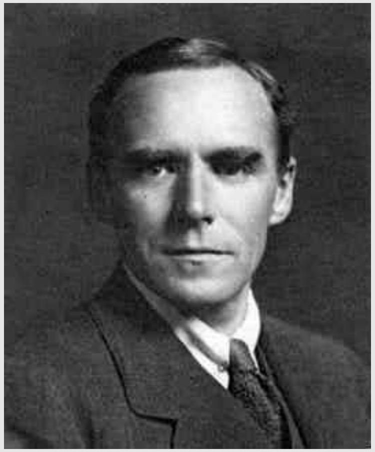
Many thanks to:
MMS team and THOR team

G. I. Taylor

Proceeding of the Royal Society of London, Series A, 1938



Geoffrey Ingram Taylor

The spectrum of turbulence

By G. I. Taylor, F.R.S.

(*Received* 1 *December* 1937)

When a prism is set up in the path of a beam of white light it analyses the time variation of electric intensity at a point into its harmonic components and separates them into a spectrum. Since the velocity of light for all wave-lengths is the same, the time variation analysis is exactly equivalent to a harmonic analysis of the space variation of electric intensity along the beam. In a recent paper Mr Simmons (Simmons and Salter 1938) has shown how the time variation in velocity at a field point in a turbulent air stream can be analysed into a spectrum. In the present paper it is proposed to discuss the connexion between the spectrum of turbulence, measured at a fixed point, and the correlation between *simultaneous* values of velocity measured at two points.

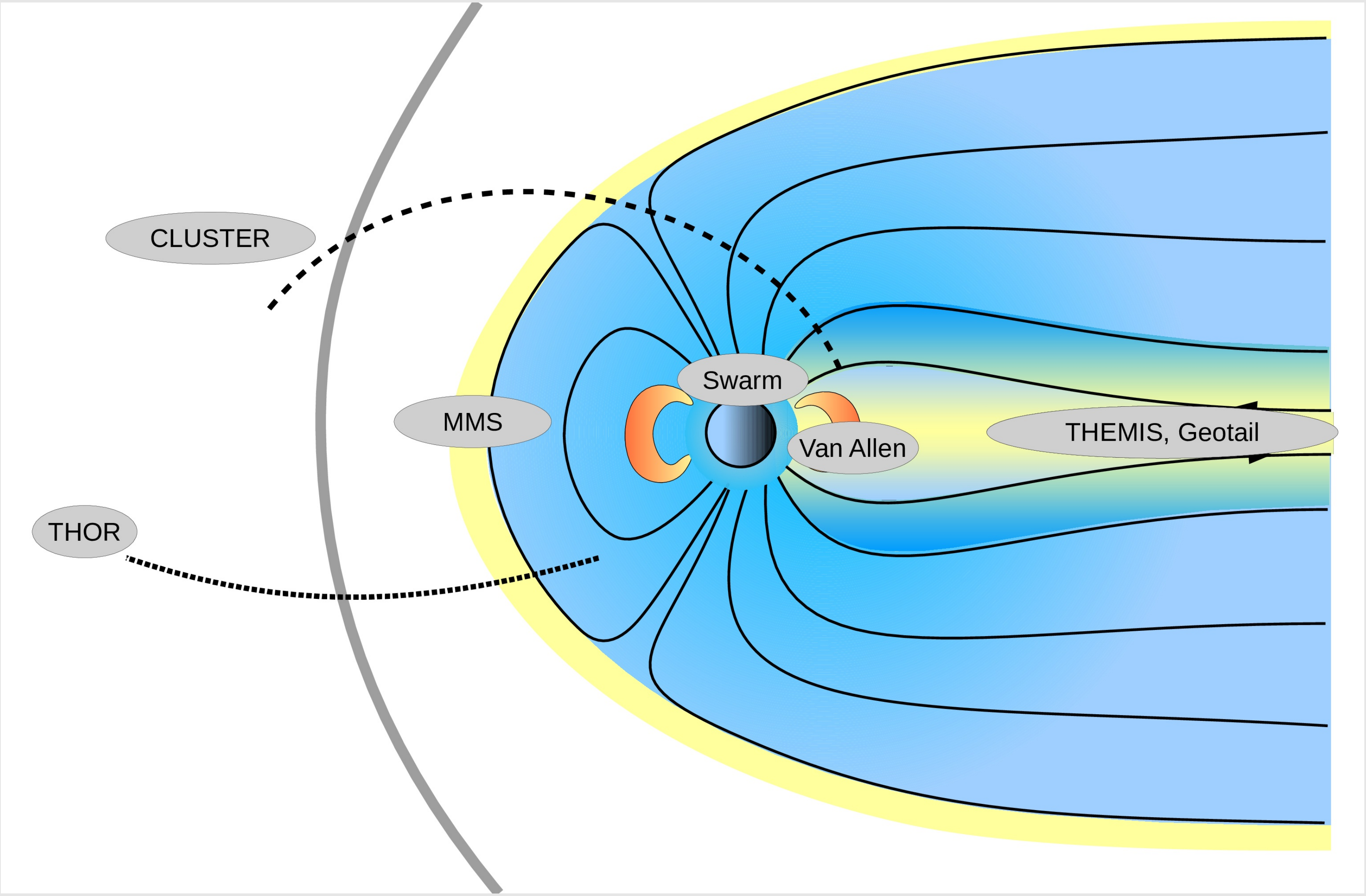
If the velocity of the air stream which carries the eddies is very much greater than the turbulent velocity, one may assume that the sequence of changes in u at the fixed point are simply due to the passage of an unchanging pattern of turbulent motion over the point, i.e. one may assume that

$$u = \phi(t) = \phi\left(\frac{x}{U}\right), \tag{7}$$

Space plasma missions

	ESA	NASA	Japan
1990's		WIND ('94) Polar ('96)	Geotail ('92)
2000's	Cluster ('00)	THEMIS ('07)	
2010's	Swarm ('13)	Van Allen ('12) MMS* ('15)	Erg ('16)
2020's	THOR ('25)		

Target regions



Mission targets

Magnetosphere in situ

Cluster, THEMIS, Swarm, MMS, Van Allen, Erg...

Magnetosphere remote sensing

X-ray imaging?

Fundamental plasma processes

Cluster, MMS, THOR

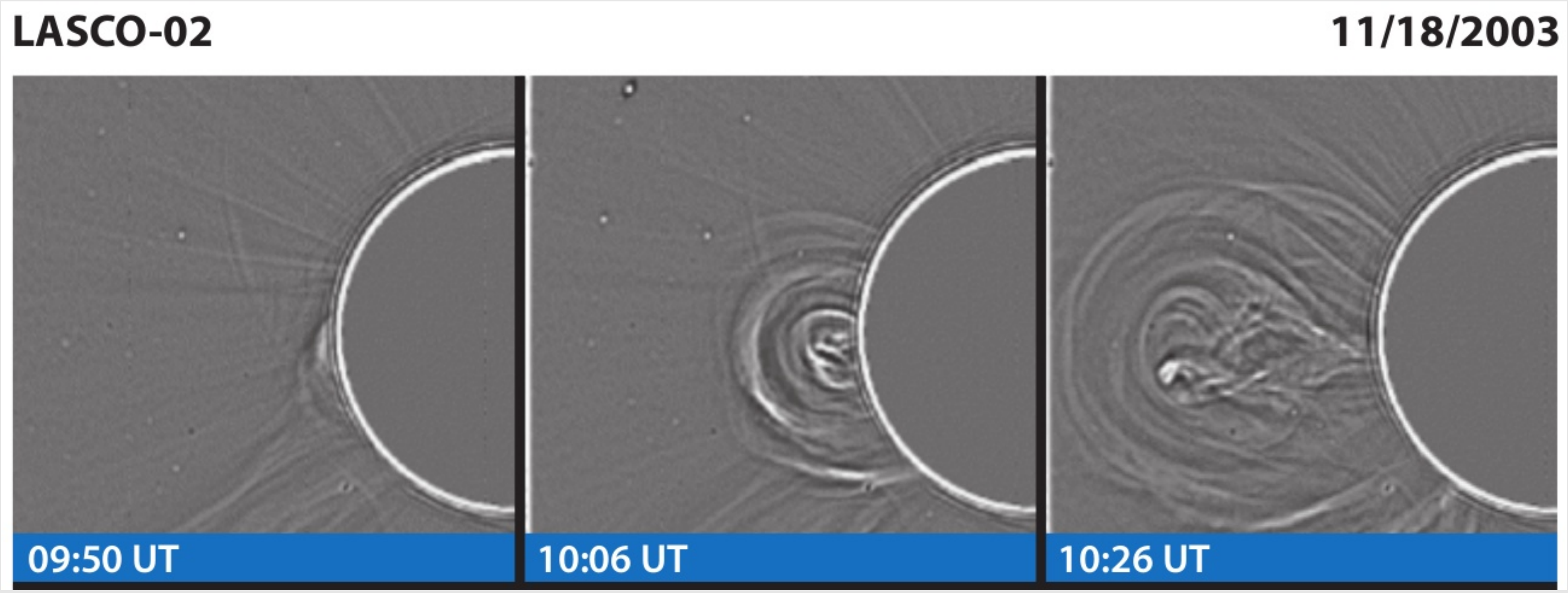
Space weather

Deep Space Climate Observatory
(ACE replacement)

Fundamental plasma problems

Colissionless shocks	Cluster
Turbulence	Cluster
Waves and instabilities	
Magnetic reconnection	MMS
Dynamo mechanism (MHD)	
Particle heating & acceleration	THOR

Magnetic reconnection



Magnetic reconnection

Generalized Ohm's law

$$\frac{\partial \boldsymbol{B}}{\partial t} = \nabla \times (\boldsymbol{u} \times \boldsymbol{B}) + \eta \nabla^2 \boldsymbol{B} + \nabla \times \left(\frac{1}{n_\mathrm{e} e} \boldsymbol{j} \times \boldsymbol{B} - \frac{1}{n_\mathrm{e} e} \nabla \cdot \underline{\underline{\boldsymbol{P}}}_\mathrm{e} + \frac{m_\mathrm{e}}{n_\mathrm{e} e^2} \frac{\partial \boldsymbol{j}}{\partial t} \right)$$

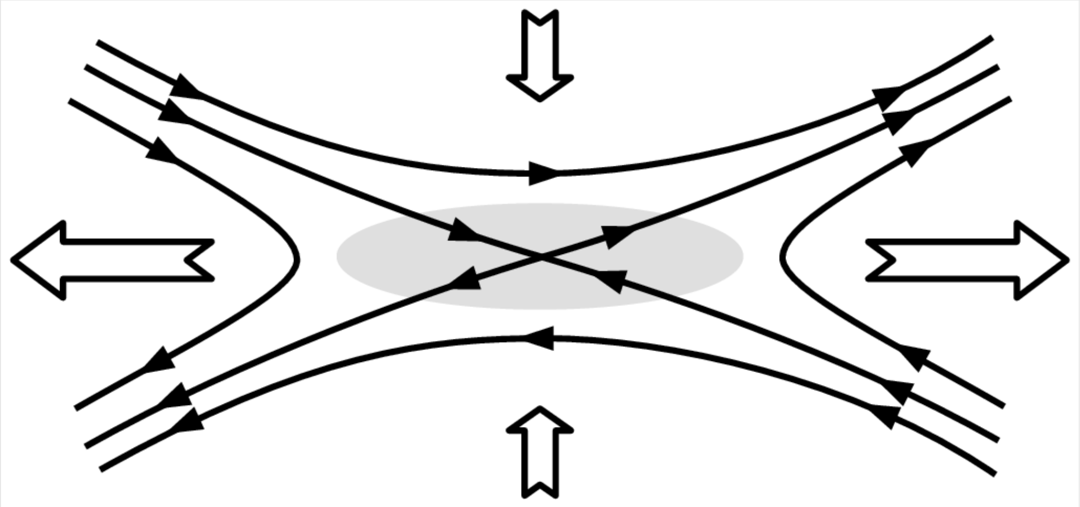
convection

diffusion or resistivity

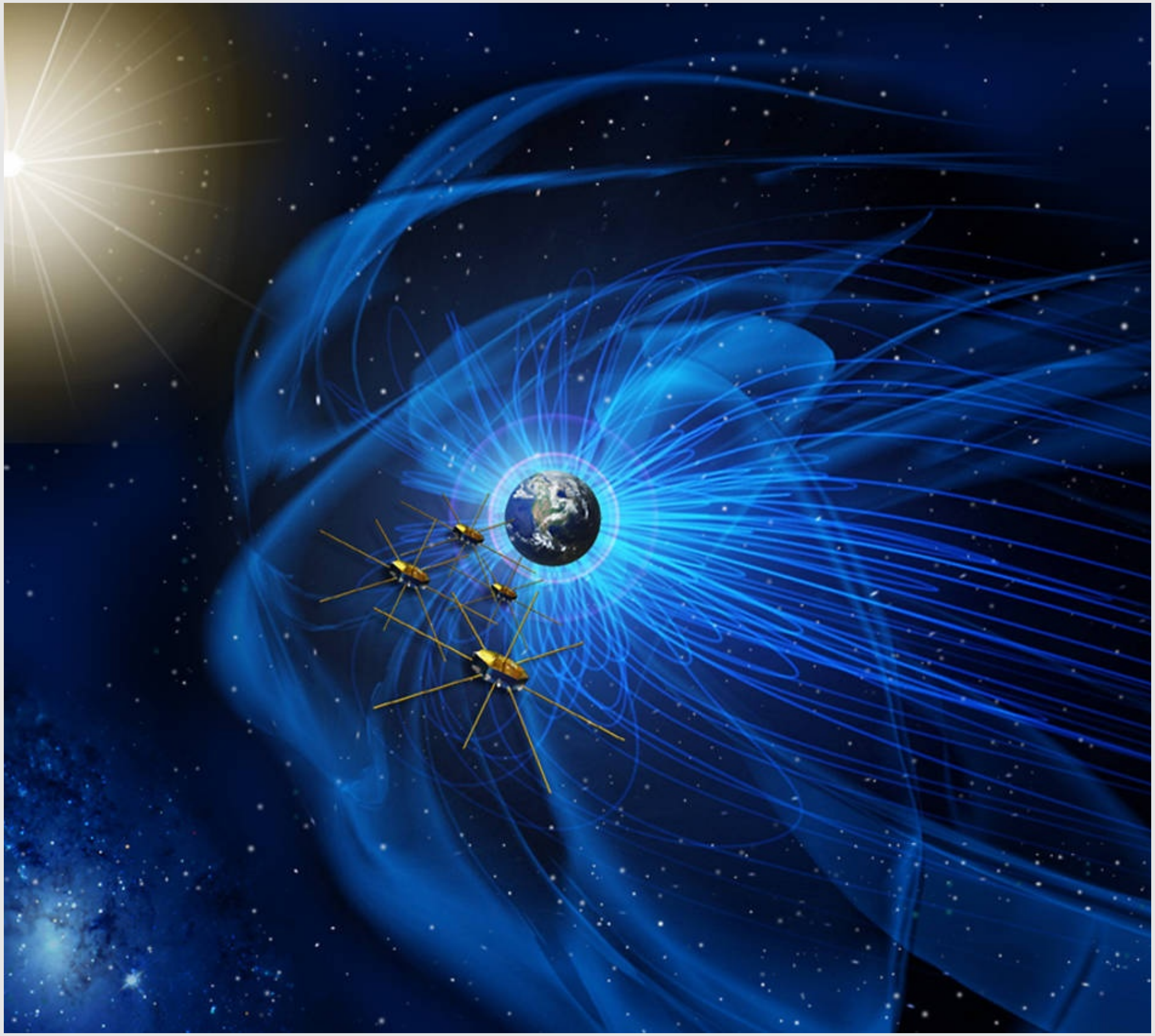
Hall term (ion-electron charge separation)

electron pressure and stress

electron inertia



MMS (Magnetospheric Multi-Scale)

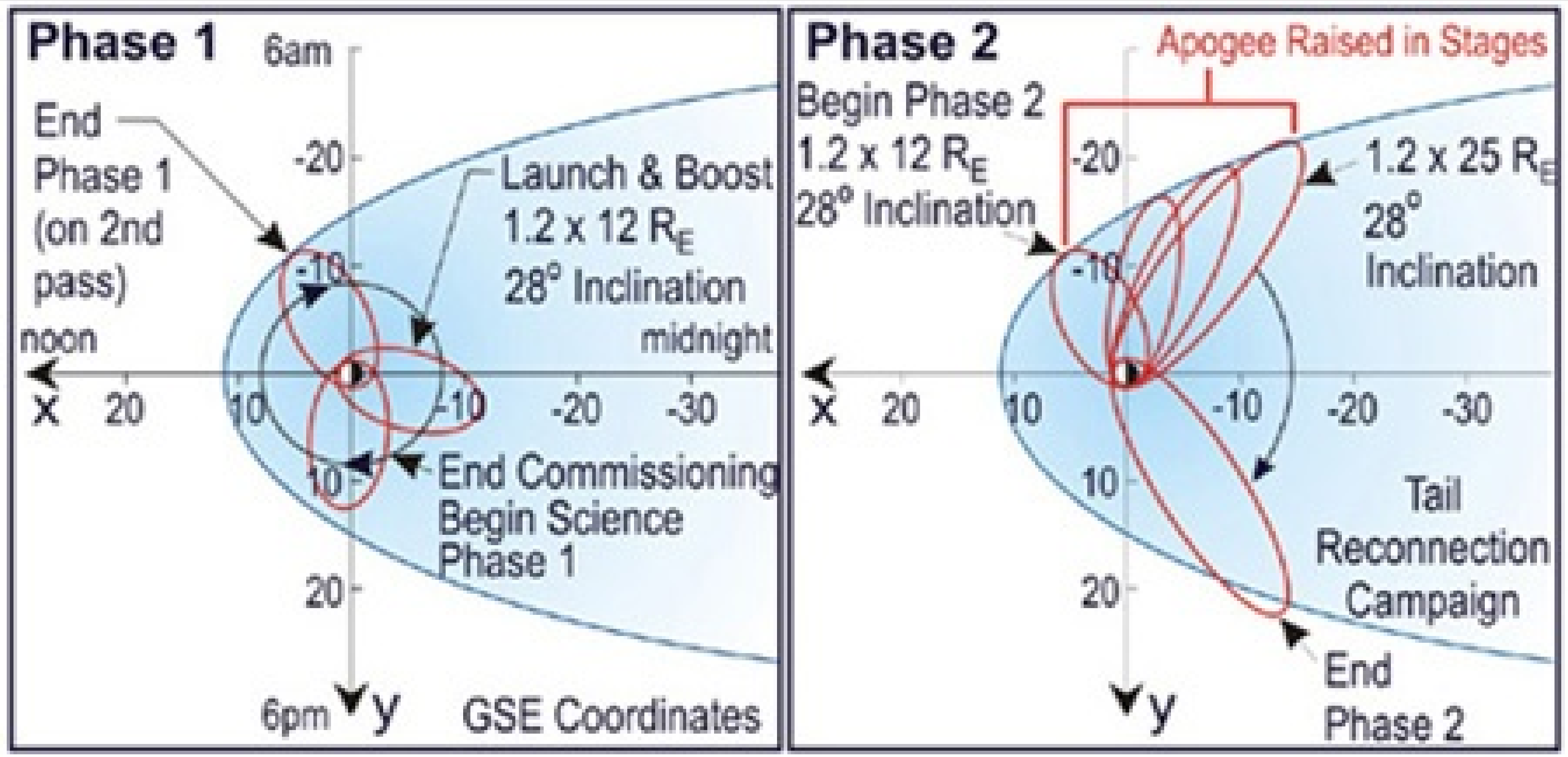


MMS (Magnetospheric Multi-Scale)

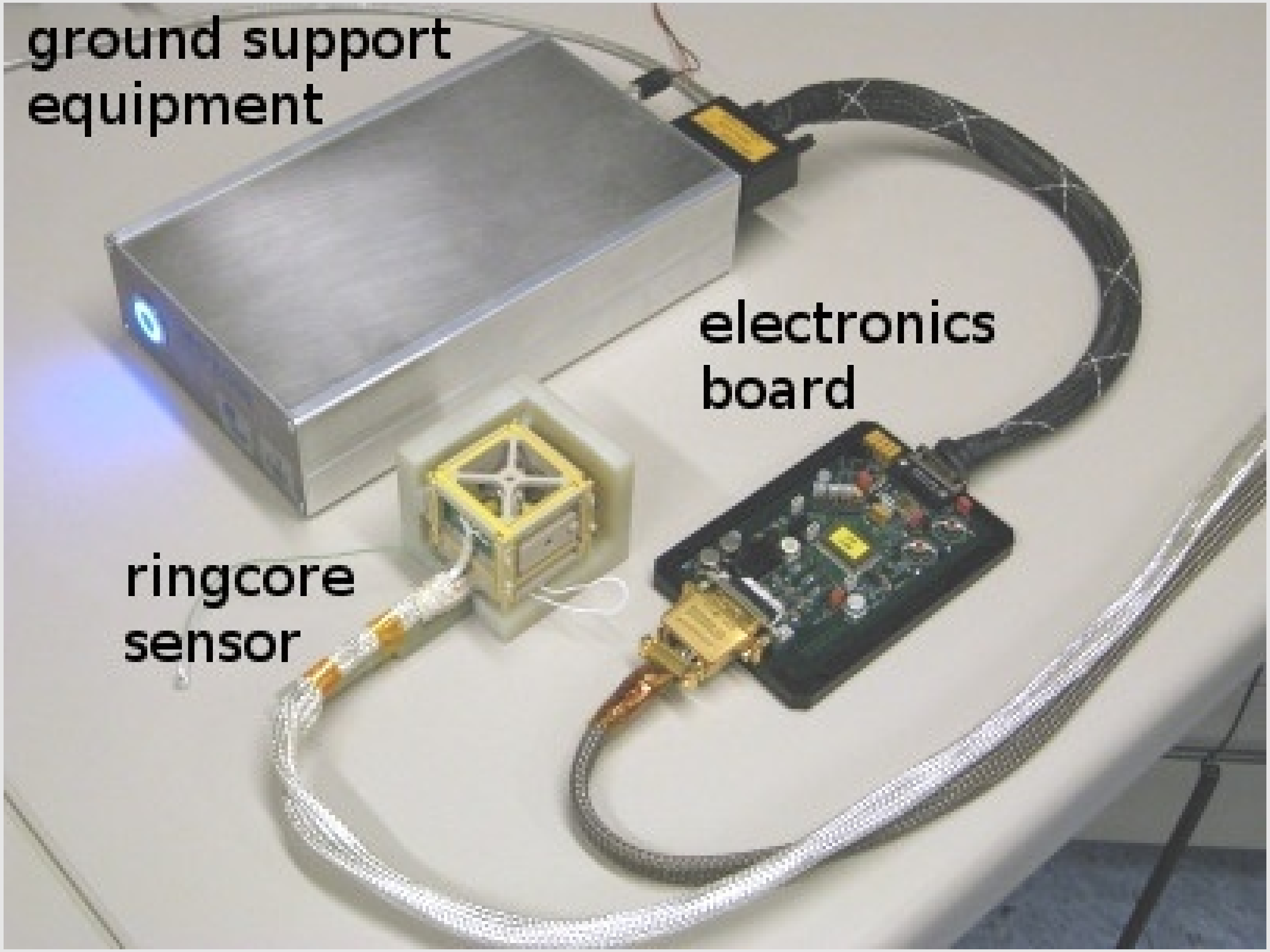
4 spacecraft in assembly

Launch on 12 Mar. 2015

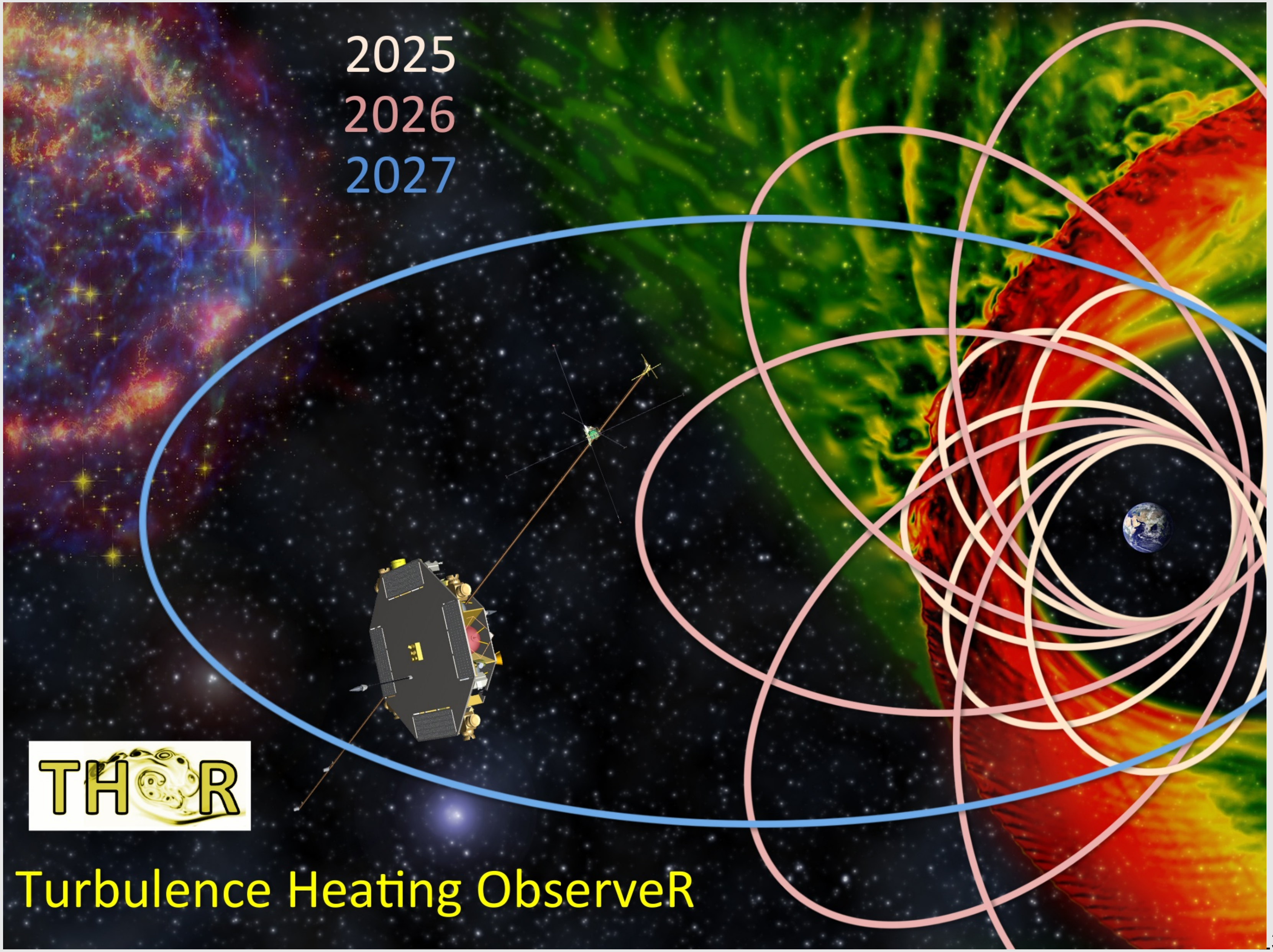
MMS (Magnetospheric Multi-Scale)



MMS magnetometer



THOR (Turbulence Heating Observer)



THOR - Motivation

Motivation
Dissipation mechanisms remain unsolved
in collisionless plasmas.

Applications
Heating problems (solar corona, solar wind, accretion disks)
Cosmic ray scattering in interstellar medium

Idea
In situ measurements of 3-component magnetic and
electric field
High-resolution and high-sampling distribution functions
of electrons and ions
Earth magnetosheath, foreshock, and near-Earth solar wind

THOR design

THOR

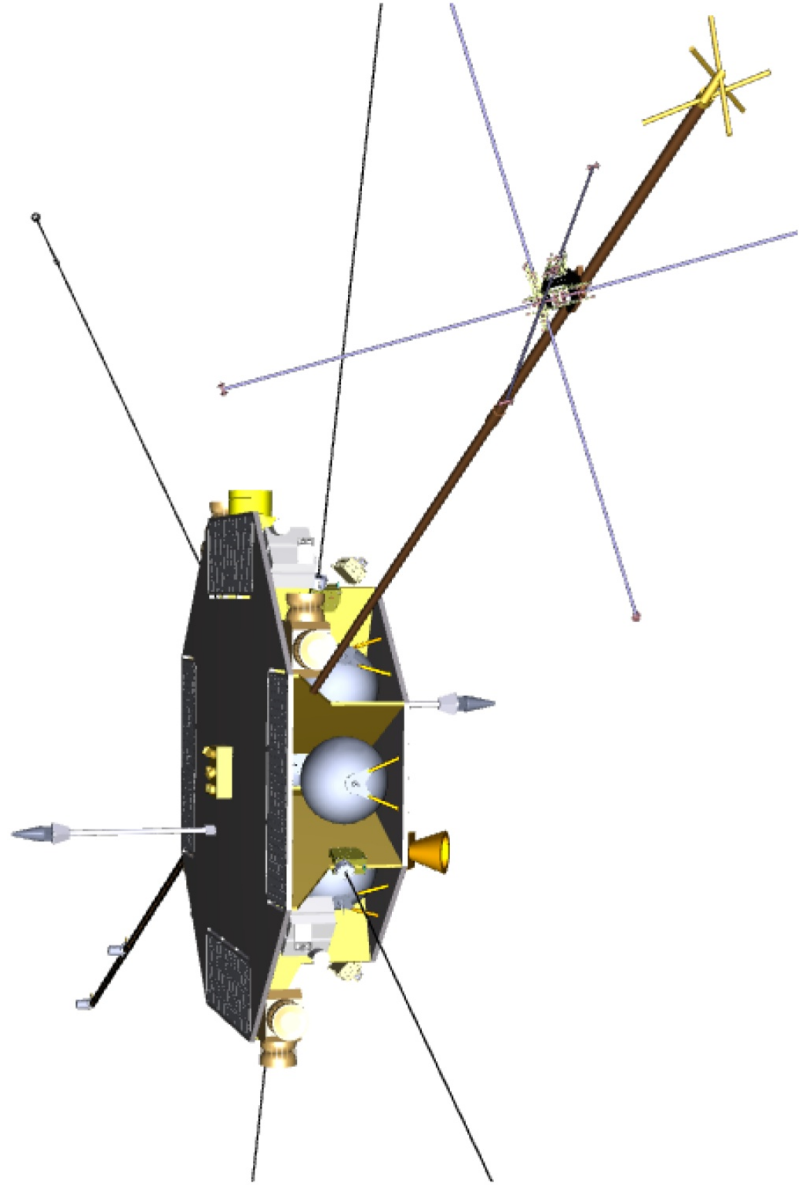
- Sun-pointer
- Slow spinner (2rpm)
- Advantages for E fields and for particle instruments

OHB SWEDEN

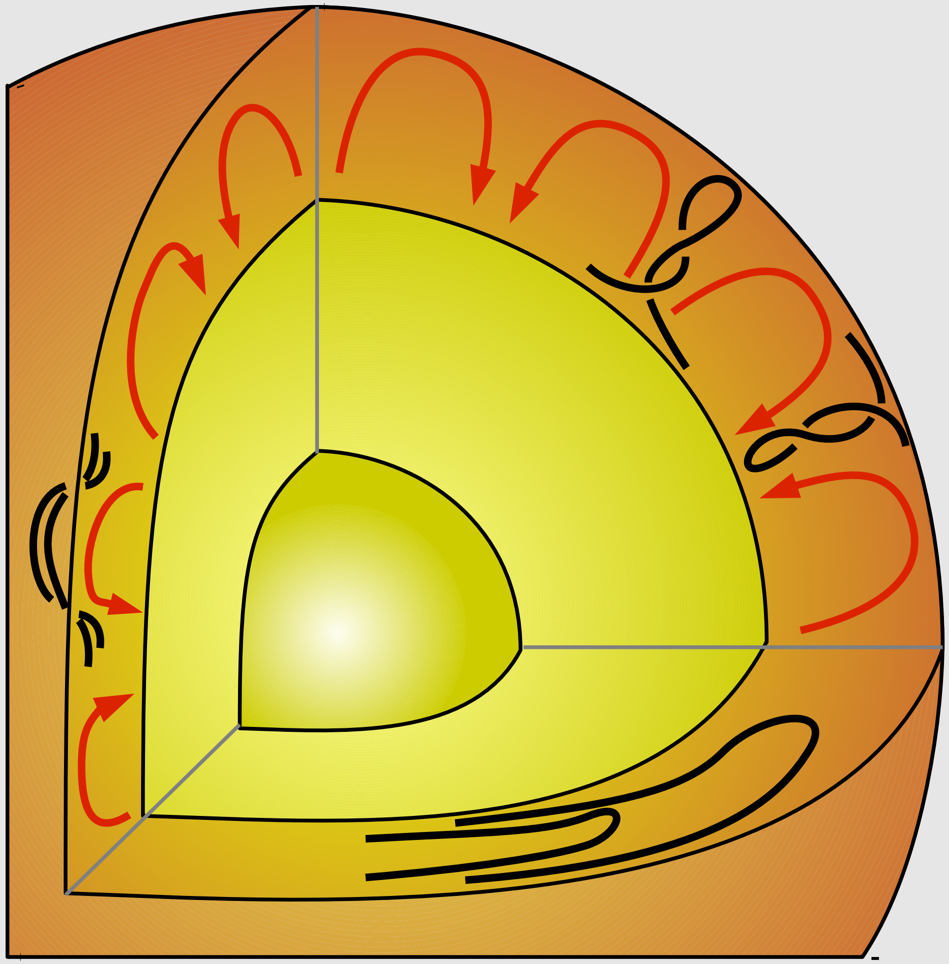
Mission profile

Eric Clacey

OHB Sweden



Solar observations



Photon measurements

SOHO, Hinode, STEREO, SDO, IRIS, Solar Orbiter

In situ measurements

Solar Orbiter

Solar Probe Plus

Internal structure diagnosis

helioseismology

neutrino measurements