Chinese Geomagnetic Satellite (CGS) Mission

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- Scientific Background
- Scientific Aims & Objectives
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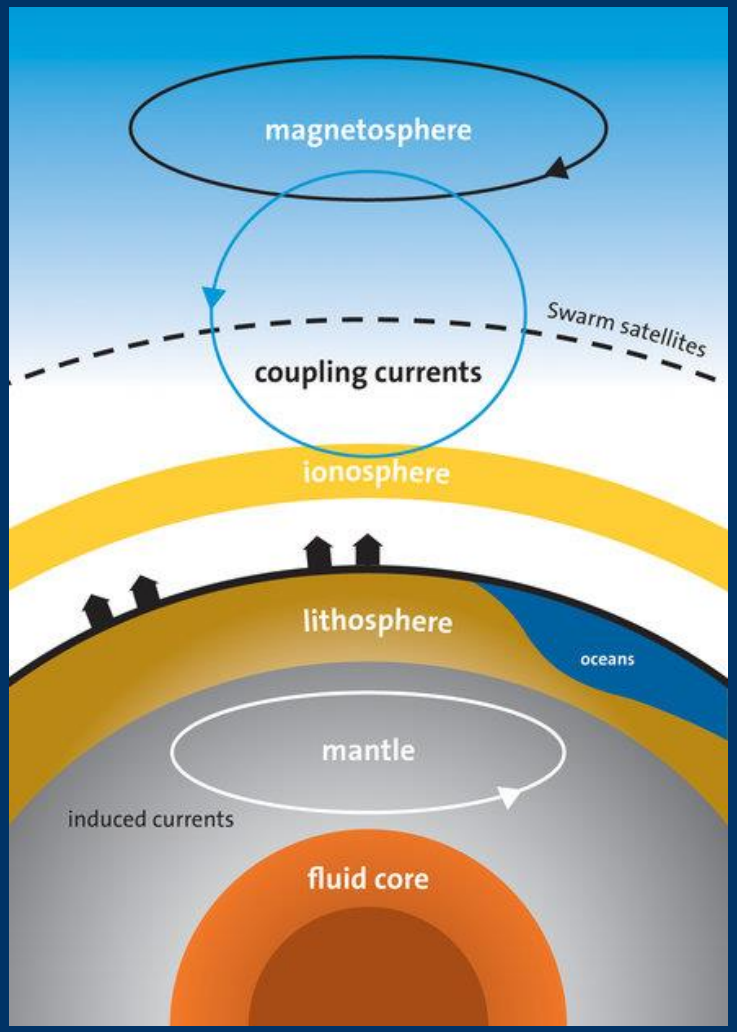
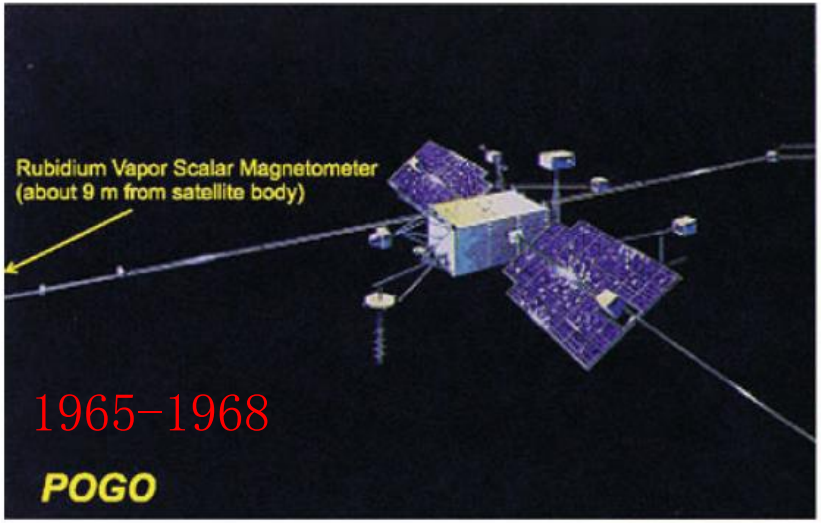
Scientific Background

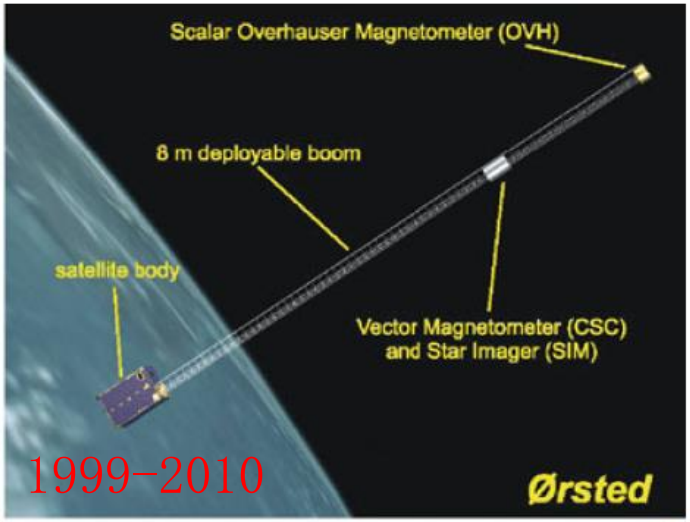
Geomagnetic Field Coupling

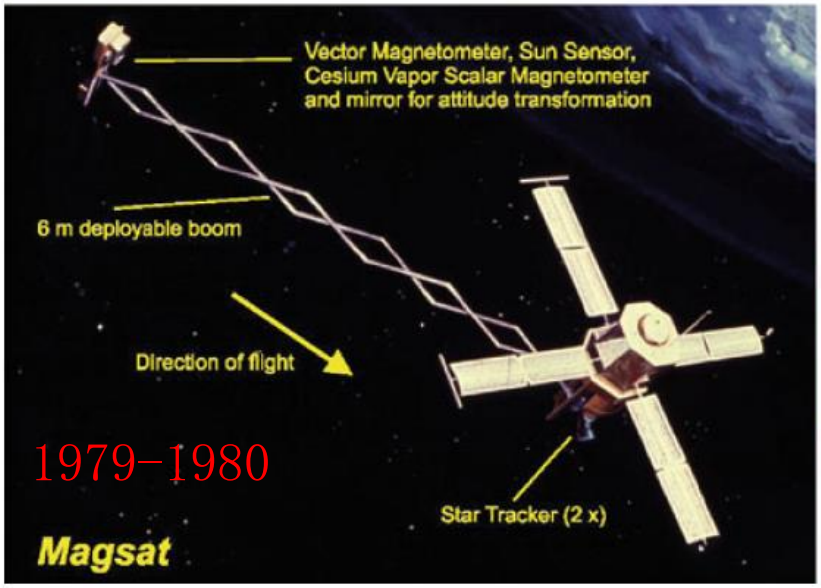


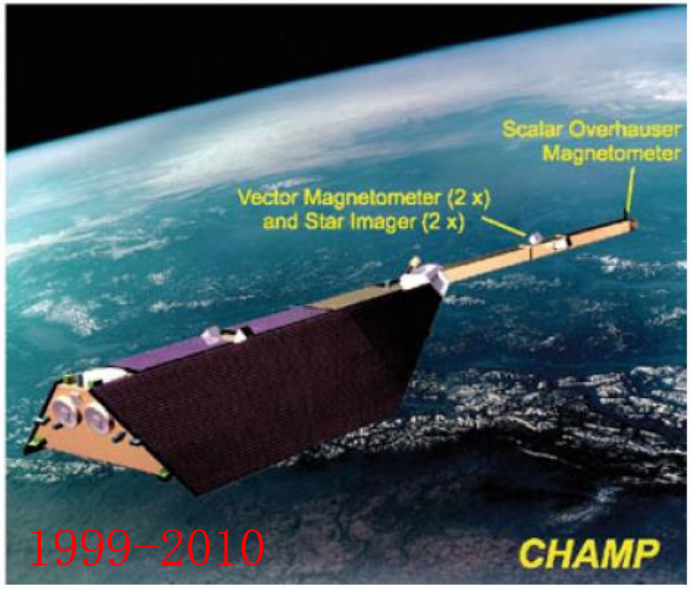
The challenge of the historic *geomagnetic satellite* mission is related to the sophisticated separation of the various sources of magnetic field, and the accurate determination of the spatial and temporal structure of them all.

Heritage


Rubidium Vapor Scalar Magnetometer
(about 9 m from satellite body)
1965–1968
POGO


Scalar Overhauser Magnetometer (OVH)
8 m deployable boom
satellite body
Vector Magnetometer (CSC)
and Star Imager (SIM)
1999–2010
Ørsted

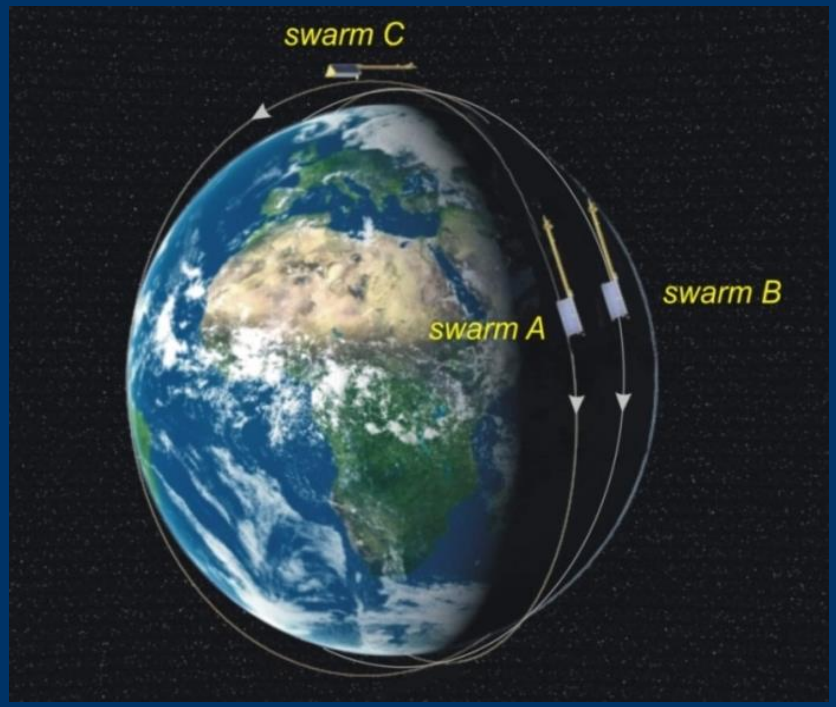

Vector Magnetometer, Sun Sensor,
Cesium Vapor Scalar Magnetometer
and mirror for attitude transformation
6 m deployable boom
Direction of flight
1979–1980
Star Tracker (2 x)
Magsat


Scalar Overhauser
Magnetometer
Vector Magnetometer (2 x)
and Star Imager (2 x)
1999–2010
CHAMP

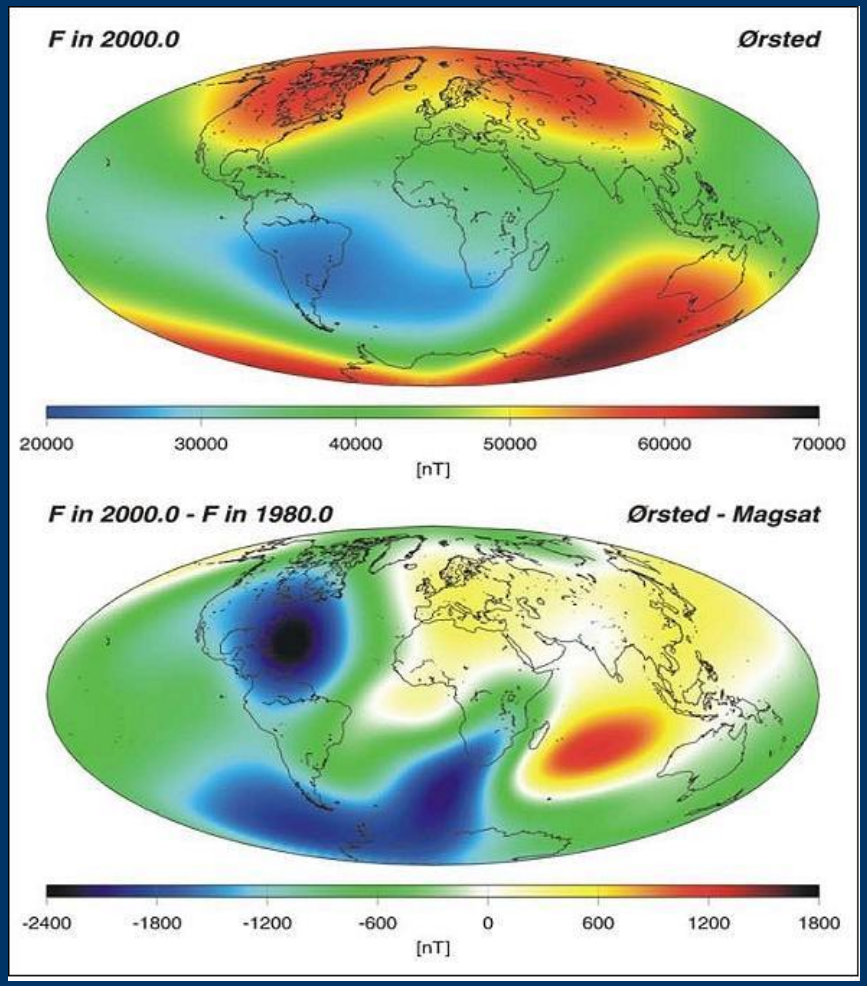
SWARM (2013)

nature International weekly journal of science

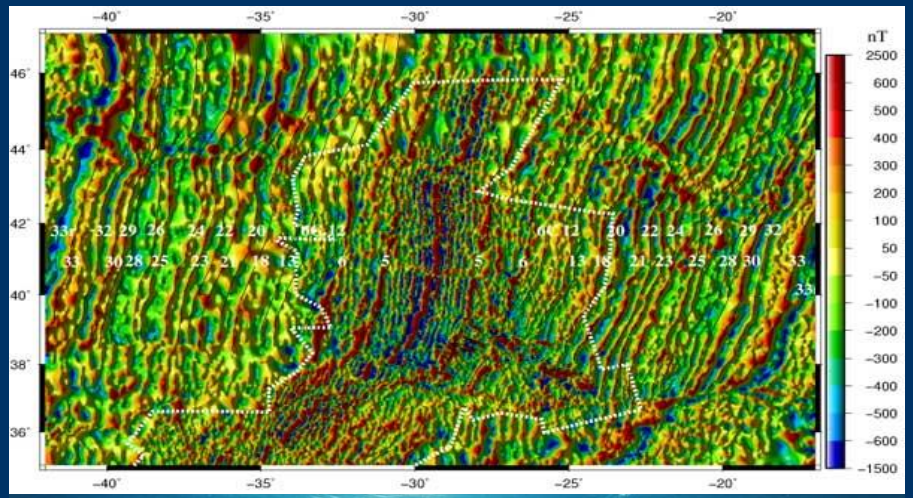
Satellite trio will unravel mysteries of planet's inner dynamo and could even find iron mines from space.

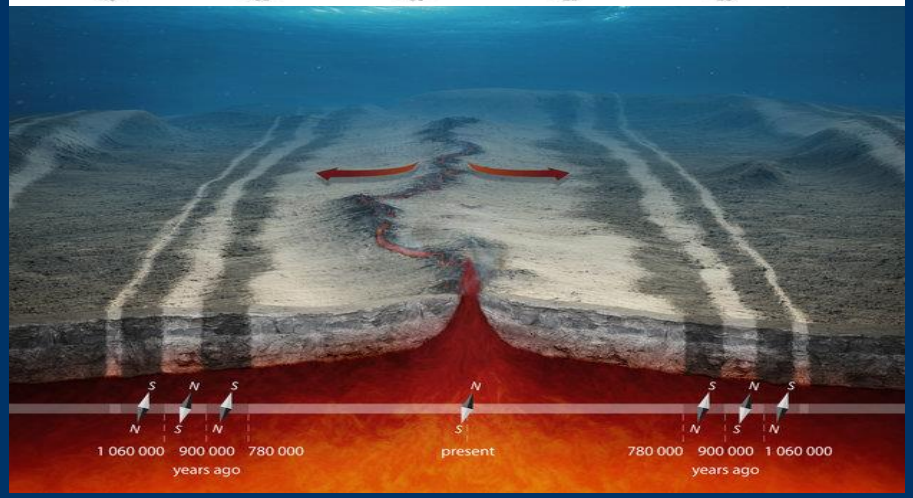


Main Field



Crust Field





Frontier Science

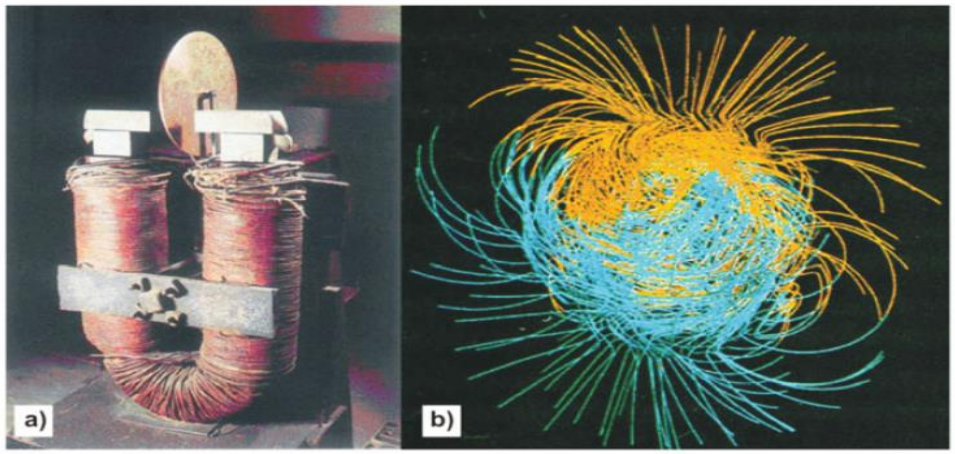
"In more modern times Einstein, shortly after writing his special relativity paper in 1905, described the problem of the earth's magnetic field as being one of the five most important unsolved problems in physics."

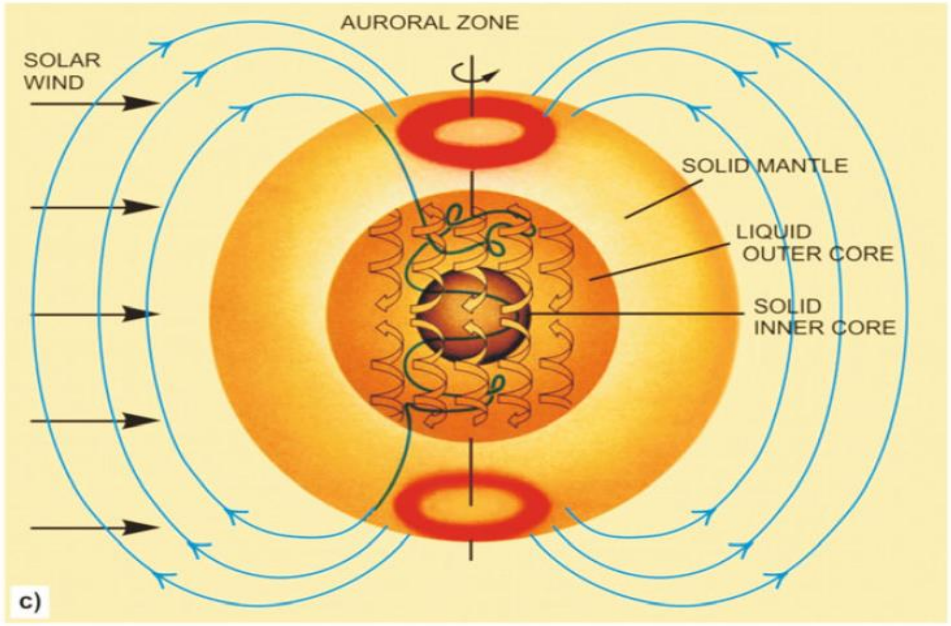
He wrote: Such generation of fields is not predicted by Maxwell's theory. It appears that here nature indicates to us a fundamental fact.

At 1924, Einstein noted the hypothesis that the magnetic field of the earth result from a slight difference between the charge of the proton and electron.

Einstein and his colleagues immerse themselves for many hours everyday in an experimental study to establish his hypothesis. They have not yet sorted out caprices of the string electrometer.

In 1929, Einstein and de Haas extended the conclusion to the rotation of the earth (the geomagnetic dynamo) as well.

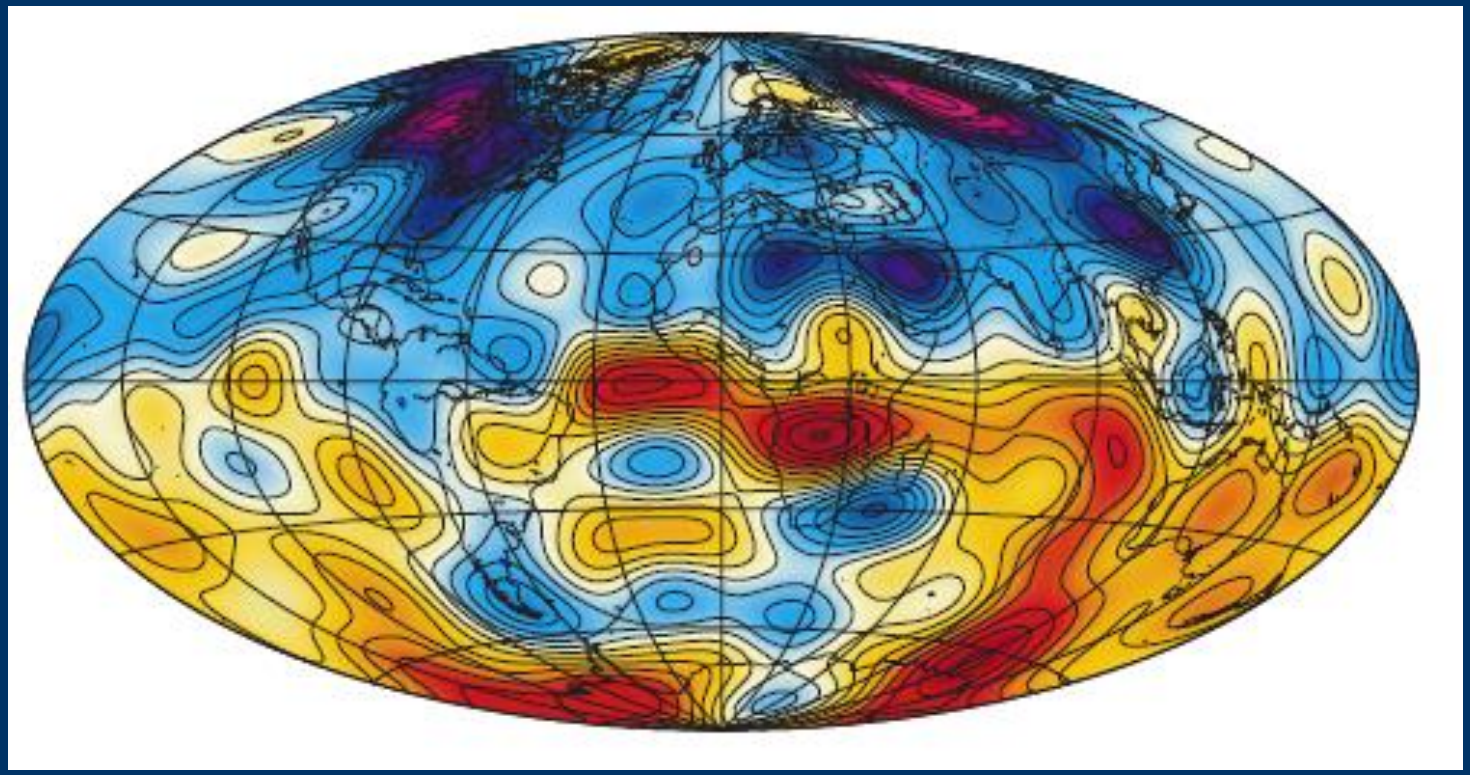




Larmor, 1919,
self-exciting dynamo

Small-scale structure of the geodynamo inferred from Oersted and Magsat satellite data

(Hulot et al., Nature, 2002)

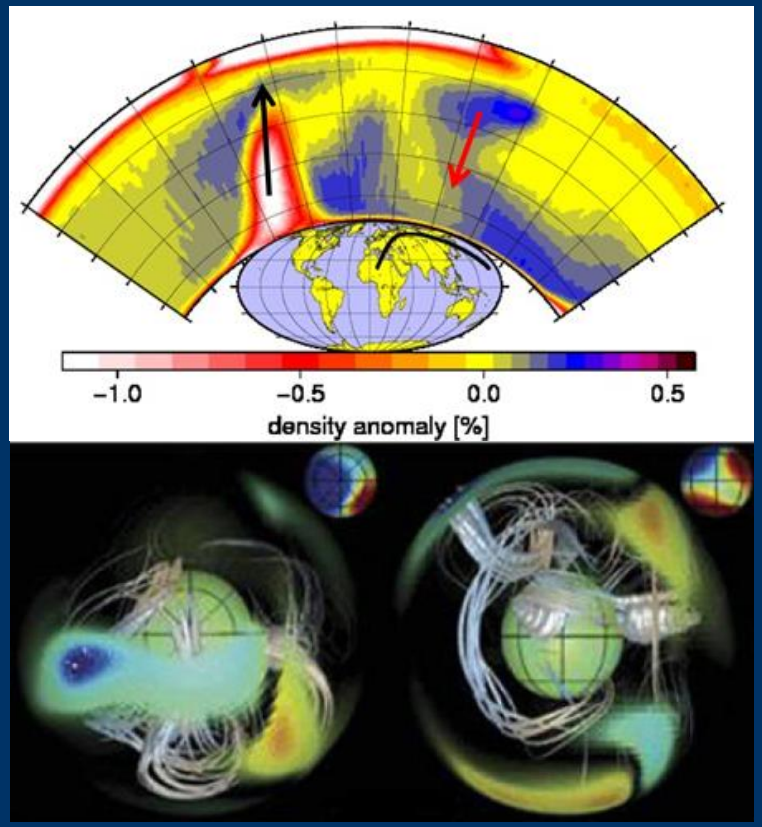


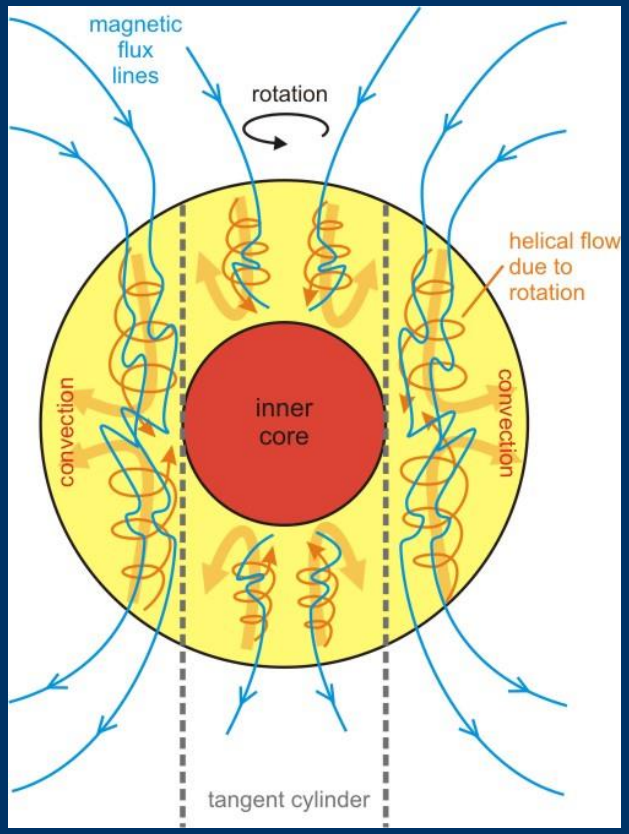
- High-degree spherical harmonic models of the geomagnetic field
- Found these variations to be small below the Pacific Ocean, and large at polar latitudes and in a region centred below southern Africa.

Possible links between long-term geomagnetic variations and whole-mantle convection processes

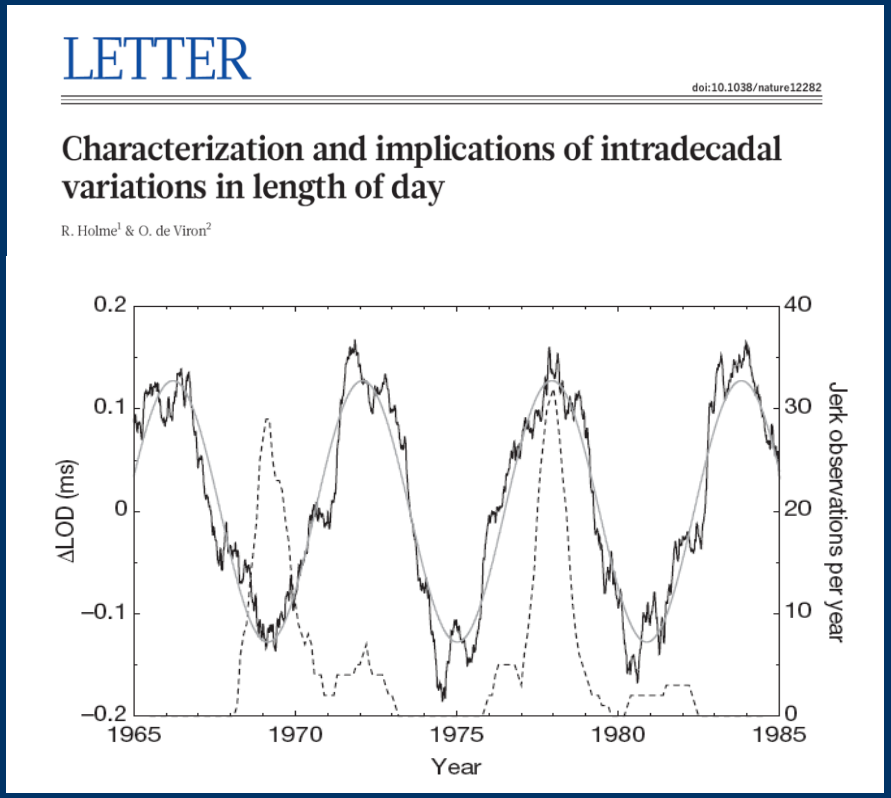
(Biggin et al., Nature Geoscience, 2012)

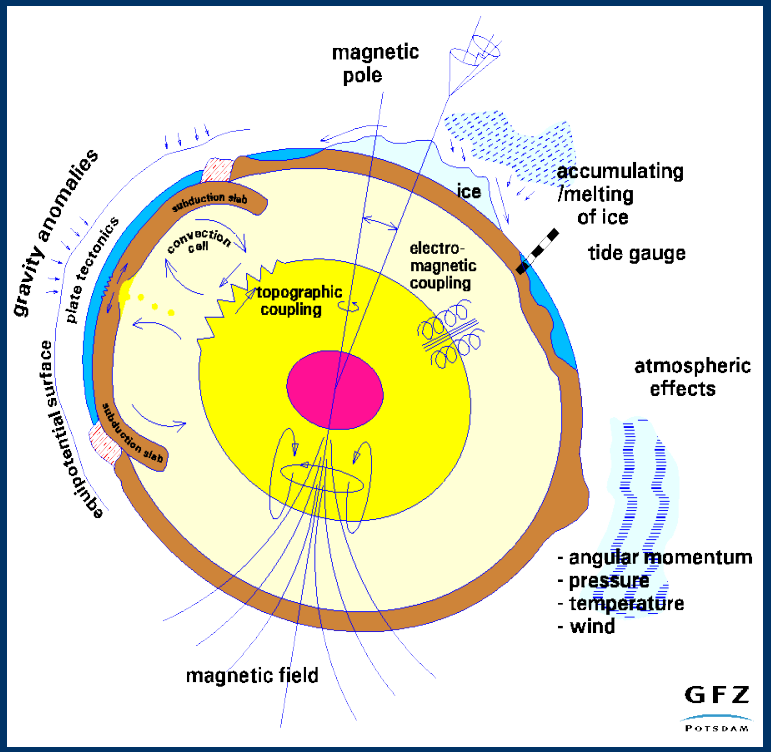
CMB heat flow





Core-mantle coupling and Earth's rotation

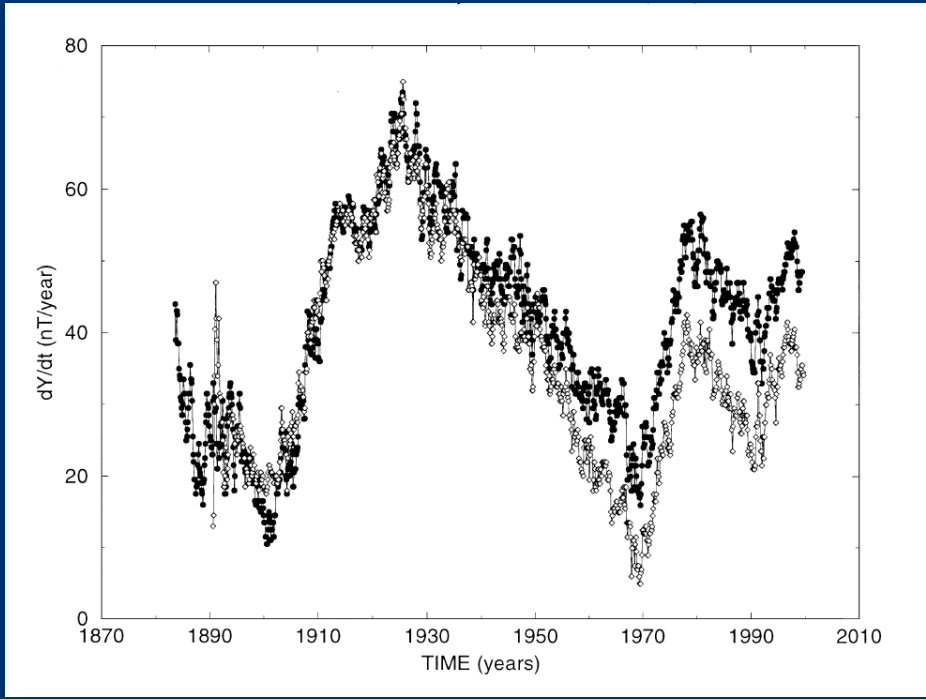




(Holme and Viron, Nature, 2013)

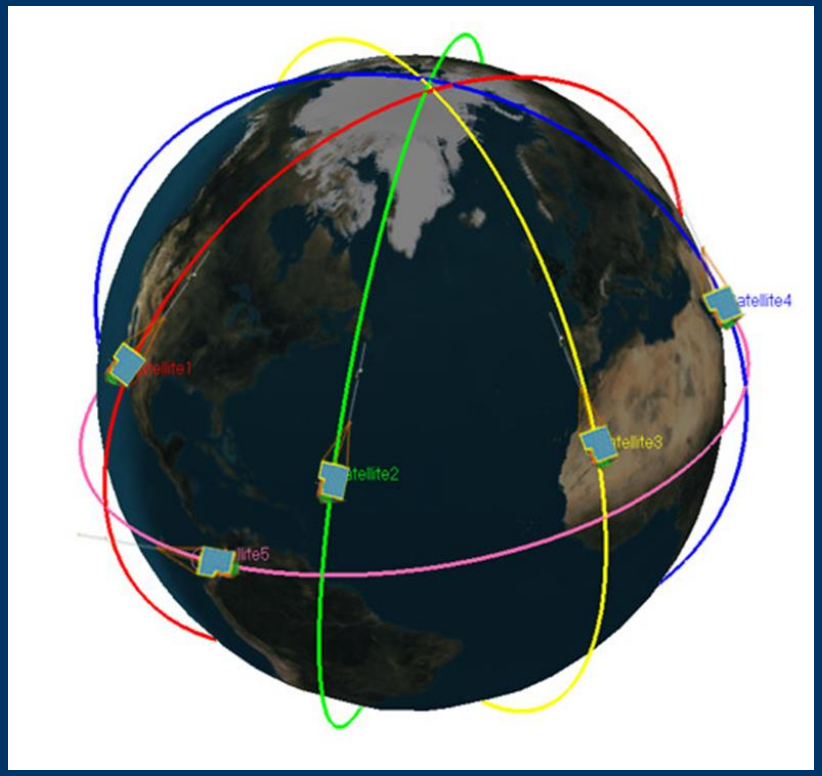
On decadal timescales of variations in Earth's rotation , the dominant contribution is from angular momentum exchange between the solid mantle and fluid outer core.

The secular variation with period of 6~10 years of the East magnetic component (dY/dt)



The magnetic field is maintained against ohmic decay by a dynamo mechanism. The latter takes place, within the Earth's core, on longer timescales and, in all likelihood, shorter length-scales than the variations of the field that have been recorded from satellites for the past 10 years.

Planned satellite mission—CGS



- 5 satellites constellation
- 4 polar orbit + 1 equtorial orbit
- Altitude: 500 km
- Identical payload for all satellites

CGS Scientific objectives

- Map the field at the core surface. Improve on the constellation of *Swarm* by doubling sample density and local time coverage. Analyze core field secular variation and secular acceleration.

- Perform electromagnetic tomography of the mantle. The deliverable from such studies would be 3-D maps of electrical conductivity of the upper- and mid-mantle, most likely down to roughly 1500km.

- Determine the small-scale features of the lithospheric field.

- Monitor the variations of the magnetospheric-ionospheric current systems.

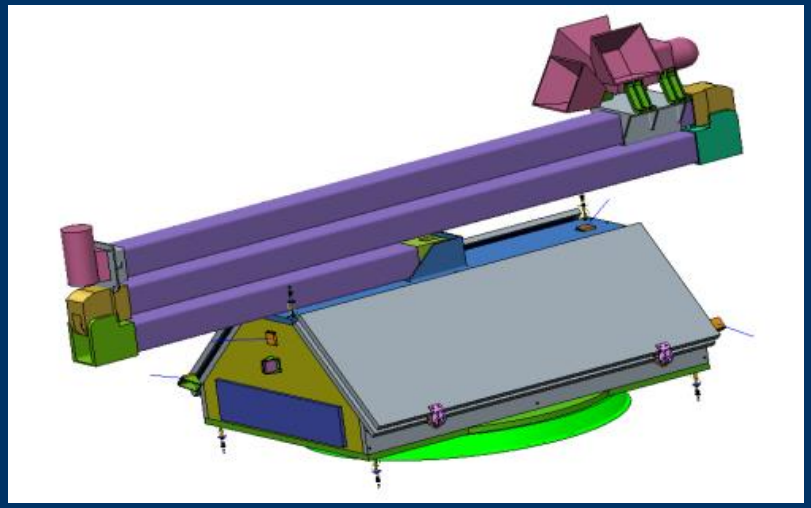
General Mission Characteristics

Spacecraft Design

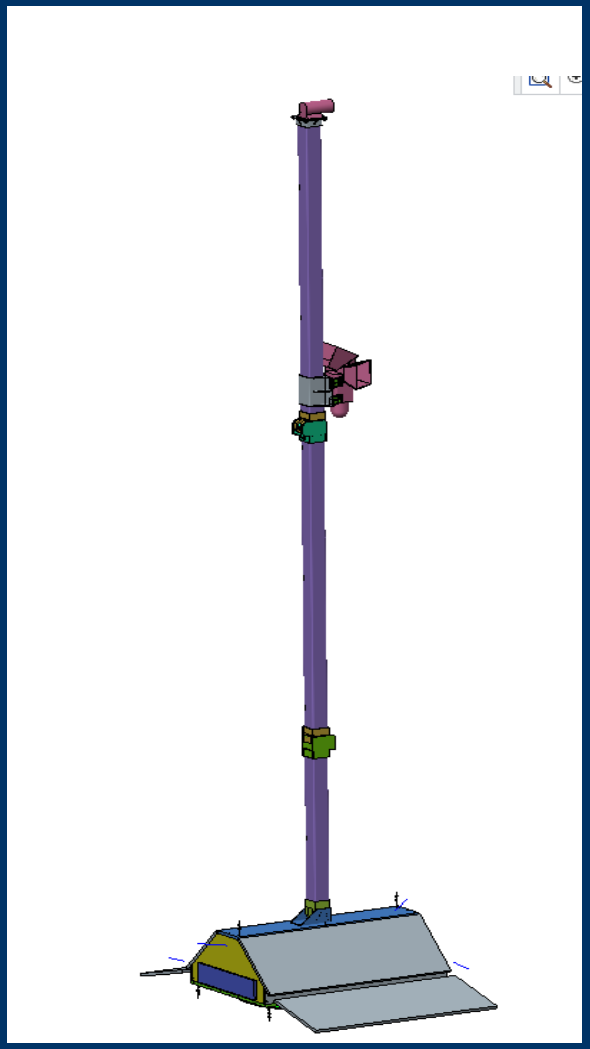
Total Mass : 108kg

Power Consumption : 69W/138W

Size in rocket:
2305mm×990mm×1176mm

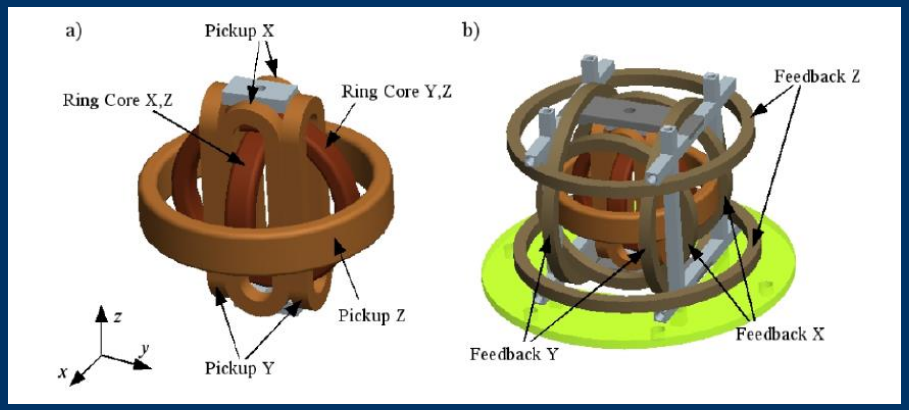


Size in-orbit:
1285mm×1880mm×6258mm

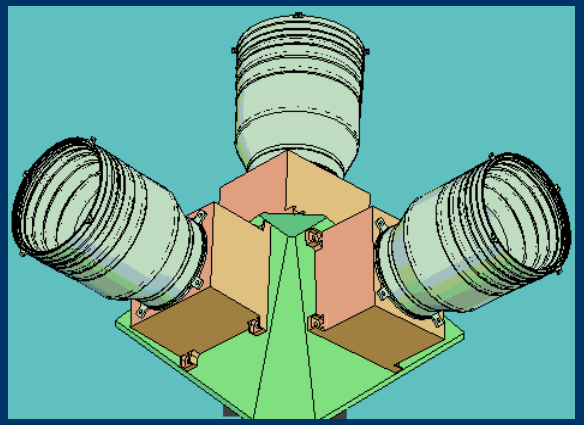


Scientific Payload

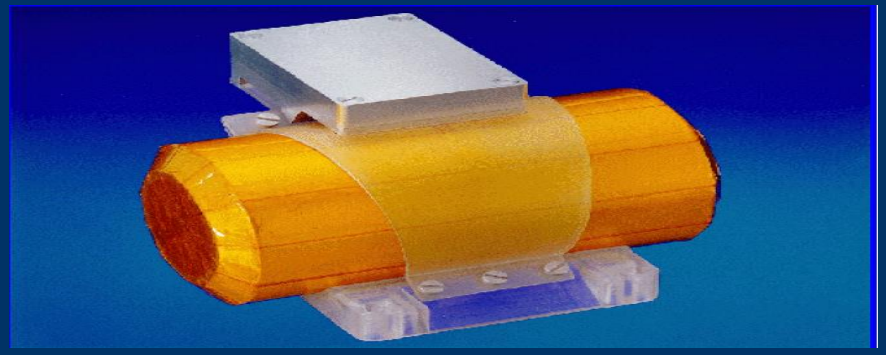
- ***Fluxgate magnetometers （FGM）***



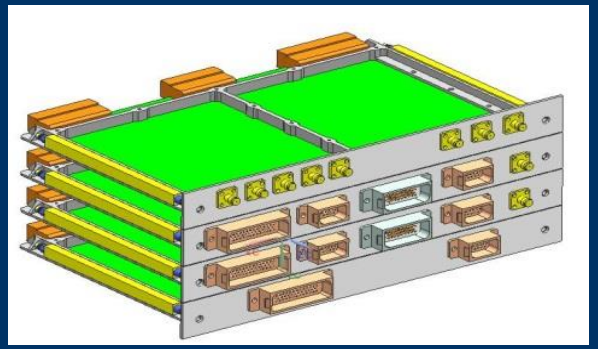
- ***Star Imager （AST）***



- ***Absolute Magnetometer （ASM）***

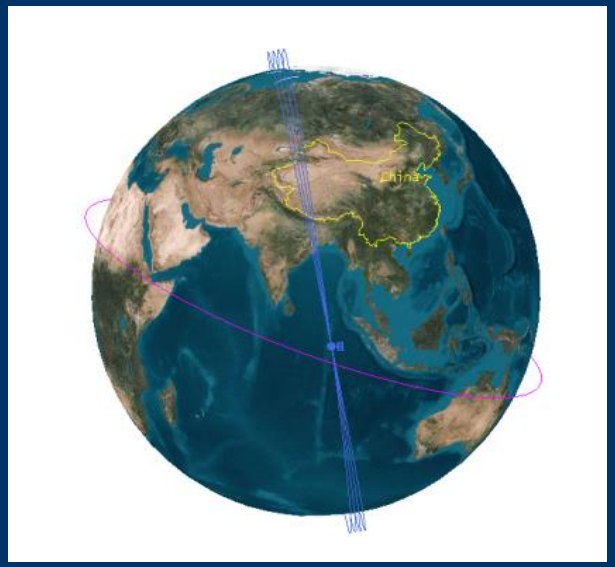


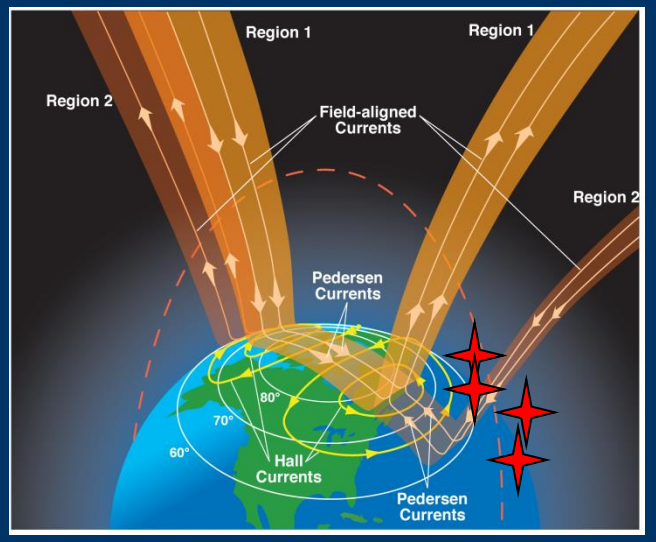
- ***GNSS***



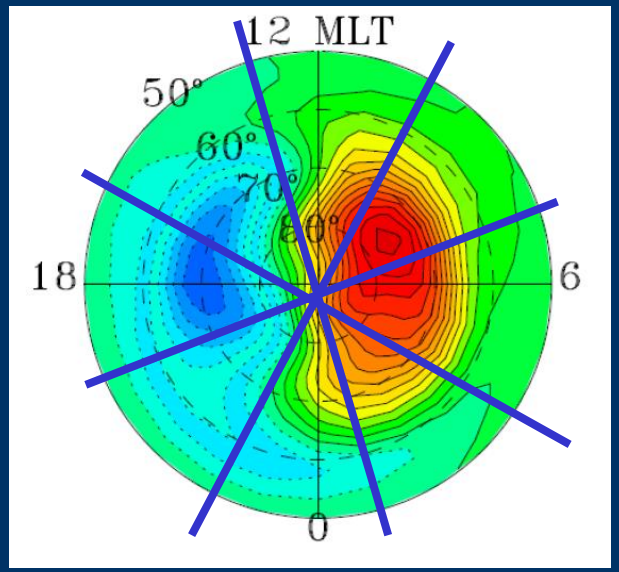
Orbit

Phase A:





Phase B:



Summary

The *CGS* concept consists of a constellation of five satellites in orbits that evolve relative to one another. Each satellite will provide high-precision and high-resolution measurements of the vector magnetic field. This leads to excellent global sampling and especially good local time sampling.

The mission will provide a new model of the near-Earth magnetic field every 2-4 months. It also will provide details of the induced currents that will give new insight into the electrical conductivity structure of the mantle. It also will supply the highest fidelity determination of the lithospheric magnetic field.


Thanks
谢谢