

Cross-Scale

An ESA mission under the Cosmic Visions 2015-25 Program
(www.cross-scale.org)

Presented on behalf of the ESA Cross-Scale Science Study Team & Cross-Scale Community by Christopher J. Owen



Mission Motivation

There are 3 universal processes which control the dynamics of plasma systems:

- Shocks
- Magnetic Reconnection
- Turbulence

These are responsible for:

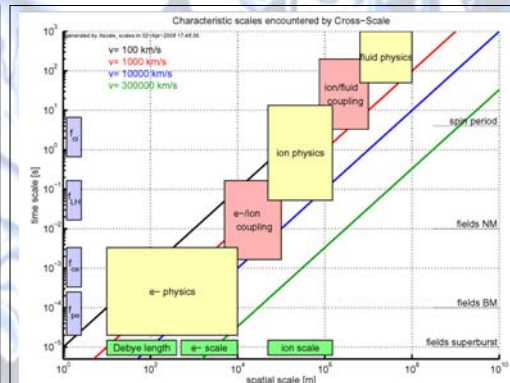
- Particle acceleration
- Energy/momentum exchange
- Transport

in space, astrophysical and laboratory plasmas

Observational Challenges

These processes:

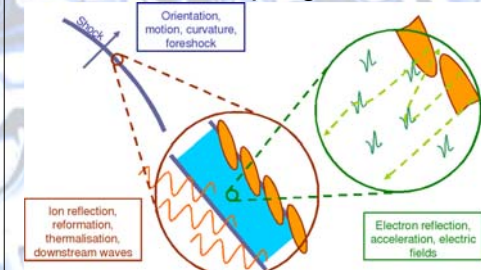
- Are time-varying;
- Are fundamentally 3D;
- Have (at least) 3 spatial & temporal scales associated with:
 - Electrons
 - Ions
 - Fluid behaviour
- which are non-linearly coupled;
- Collisionless → Kinetic;
- Complex plasma ↔ EM fields;
- Largely inaccessible directly.



Cross-Scale will target science goals addressing the *coupling* between different scales.

How does the Solar System Work?

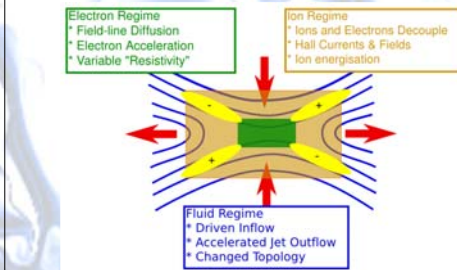
Cross-Scale Coupling at Shocks...



How do shocks accelerate and heat particles?

- Acceleration processes?
- Energy partition?
- Variability?

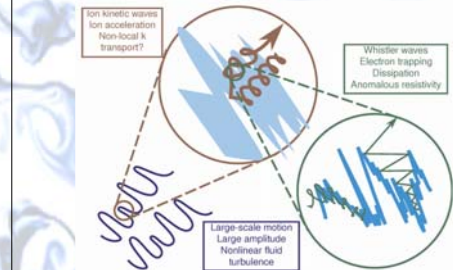
... in Reconnection...



How does reconnection convert magnetic energy?

- Initiation?
- Magnetic topologies?
- Particle acceleration?

... and in Turbulence.



How does turbulence control plasma transport?

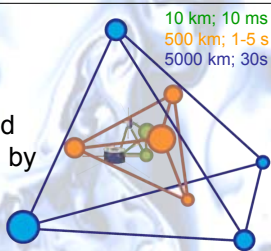
- Energy cascade?
- Anisotropies?
- Coherent Structures?

Mission Profile.

Requirements

Mission Design:

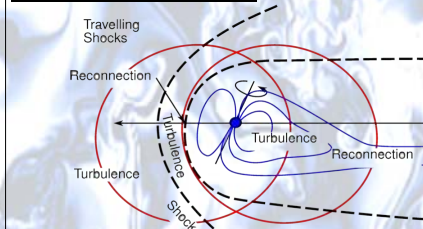
- Electron Scale: Extensive payload partially provided by JAXA SCOPE mission;
- Ion Scale: Targeted payload;
- Fluid Scale: Context payload;
- Focus: coupling between scales.



Key Concepts

- (Behaviour) ≠ Behaviour of ()
- Simultaneous multi-scale
- Near-Earth: unique *in situ* plasma laboratory

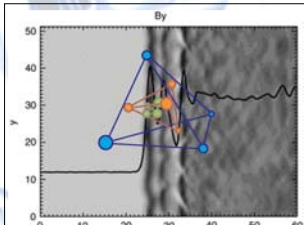
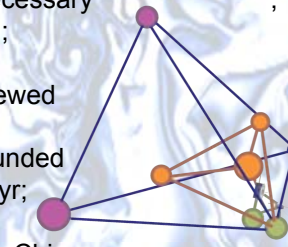
Orbit and Launch



- Launch: ≤ 7 ESA s/c on Soyuz-Fregat;
- Separate SCOPE launch for ≥ 2 JAXA s/c (launch capacity ≅ 3 moderately-equipped s/c + 600 kg – so could launch several third-party s/c);
- Thus extendable by other agencies.

Recent Activities and Evolution

- ESA Science Study Team defined SciRD and Payload Definition Document;
- Strategy: 7 s/c minimum; + partners
- Science objectives can be achieved with < 12 by shared corner and, if necessary 2-scale coupling;
- JAXA studies funded and reviewed autumn 2008;
- NASA study funded @ \$150k/yr × 2 yr;
- Interest from Canada, Russia, China.



Summary:

- The Cross-Scale mission will address fundamental questions about how solar system, astrophysical and laboratory plasmas work by simultaneously measuring the coupling between electron, ion, and fluid scales;
- The mission has widespread European and international support, is a mature concept within ESA and its member states, and is both feasible and affordable.