# ULF waves in the inner magnetosphere: an overview

D. Constantinescu C. Bunescu

Institute for Space Sciences, Bucharest

1. Energy input
2. Wave modes and instabilities
3. Resonance
4. Multi-point techniques

ULFMAG kickoff meeting, Graz, March 2014

# Energy input

1. solar wind
   - impulsive broad band
     - local near noon
     - global resonant oscilations
   - periodic variation
     - upstream waves entering the magnetosphere
     - global forced oscillations
   - velocity shear
     - local Kelvin-Helmholtz waves at magnetopause flanks
     - standing surface waves
2. tailward activity (substorms)
   - bursty bulk flows $\rightarrow$ affect mainly the PSBL
   - dipolarization $\rightarrow$ global
3. plasma convection
   - e.g. the westward drift

# Instabilities and wave modes

There are many ways in wich the plasma becomes unstable
Each condition excites different wave modes

- anisotropy — from compression / orthogonal heating
  - mirror mode
  - ion cyclotron
  - wistler
- ion beams — e.g. during substorms
  - L and R mode
  - magnetosonic
- velocity shear — at the magnetopause
  - Kelvin-Helmholtz
- mode coupling — e.g. fast - Alfvén

...

# Resonant modes

Discrete frequencies
Wave length comparable with the resonance domain

- guided waves
  - Alfvén $\rightarrow$ FLR 1D
  - Ion cyclotron $\rightarrow$ FLR? 1D
  - MP surface waves $\rightarrow$ KS 2D
- unguided waves
  - fast mode $\rightarrow$ cavity 3D

# Multi-point techniques

In essence timing / phase differencing

- timing (time domain)
  - time lag from cross correlation
  - can provide phase speed even for small $\lambda$
- wave telescope (frq domain)
  - assumes plane wave front
  - wave vector
- source locator (frq domain)
  - assumes spherical wave front
  - wave vector and distance to the source
- FLR detector (frq domain)
  - applied on ground arrays