

## JUICE Science Themes

- *Emergence of habitable worlds around gas giants*
- *Jupiter system as an archetype for gas giants*

## JUICE concept

- *European-led mission to the Jovian system*
- *JGO/Laplace scenario with two Europa flybys and high-inclination phase at Jupiter*
- *JGO model payload is fully compatible with JUICE objectives*
- *First orbiter of an icy moon*

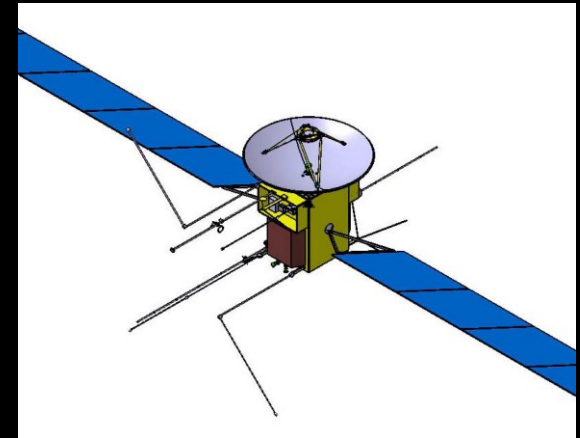
## Spacecraft Design

## Definition Phase

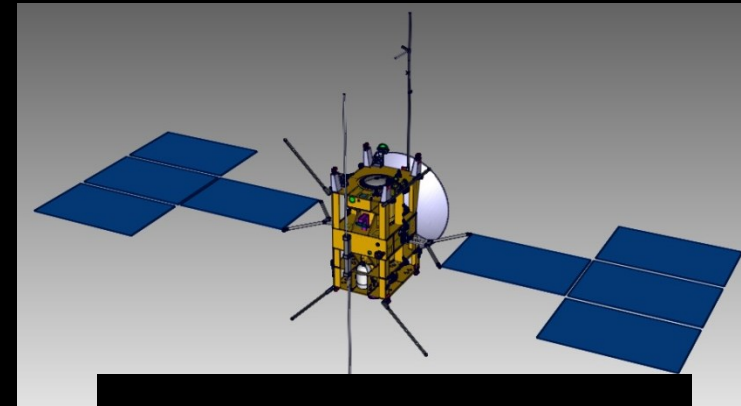
## Mission phases

- Dry mass ~1900 kg, propellant mass ~2900 kg
- High  $\Delta v$  required: 2600 m/s
- Instruments ~104 kg, ~120 – 150 W
- 3-axis stabilized s/c
- Power: solar array 60 – 70 m<sup>2</sup>, 640 – 700 W
- HGA: >3 m, fixed to body, X & Ka-band
- Data return >1.4 Gb per 8 h pass (one ground station)

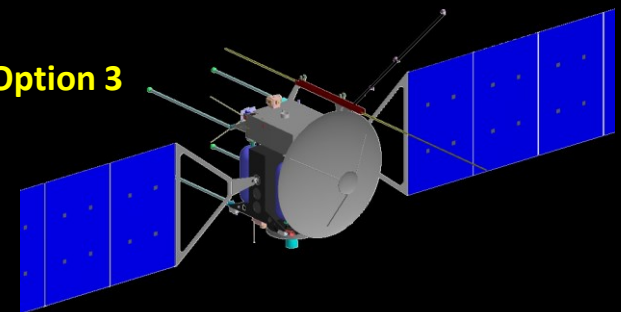
Option 1



Option 2



Option 3



Spacecraft Design

Definition Phase

Mission phases

## In Phase A-B1, instruments selected March 2013

JANUS: Camera system (UK hardware involvement, Open University)

MAJIS: Imaging Spectrometer

UVS: UV Imaging Spectrograph

SWI: Sub-millimetre Wave Instrument

GALA: Laser Altimeter

RIME: Radar

J-MAG: Magnetometer (UK PI Imperial College; Leicester Univ.)

PEP: Particle Environment Package (UK involvement, Univ. Aberystwyth; MSSL)

RPWI: Radio & Plasma Wave Investigation

3GM: Gravity

PRIDE: Radio Interferometer & Doppler Experiment (exploit VLBI to conduct radio science)

- **IPRR - end 2013/early 2014**
- **SRR - Fall 2014**
- **Mission Adoption November 2014**

***Model payload is based on heritage:***

*BepiColombo, Juno, Mars Express, Double Star,  
Venus Express, Rosetta, Dawn, Cassini, etc...*

## Spacecraft Design

## Definition Phase

## Mission phases

Launch

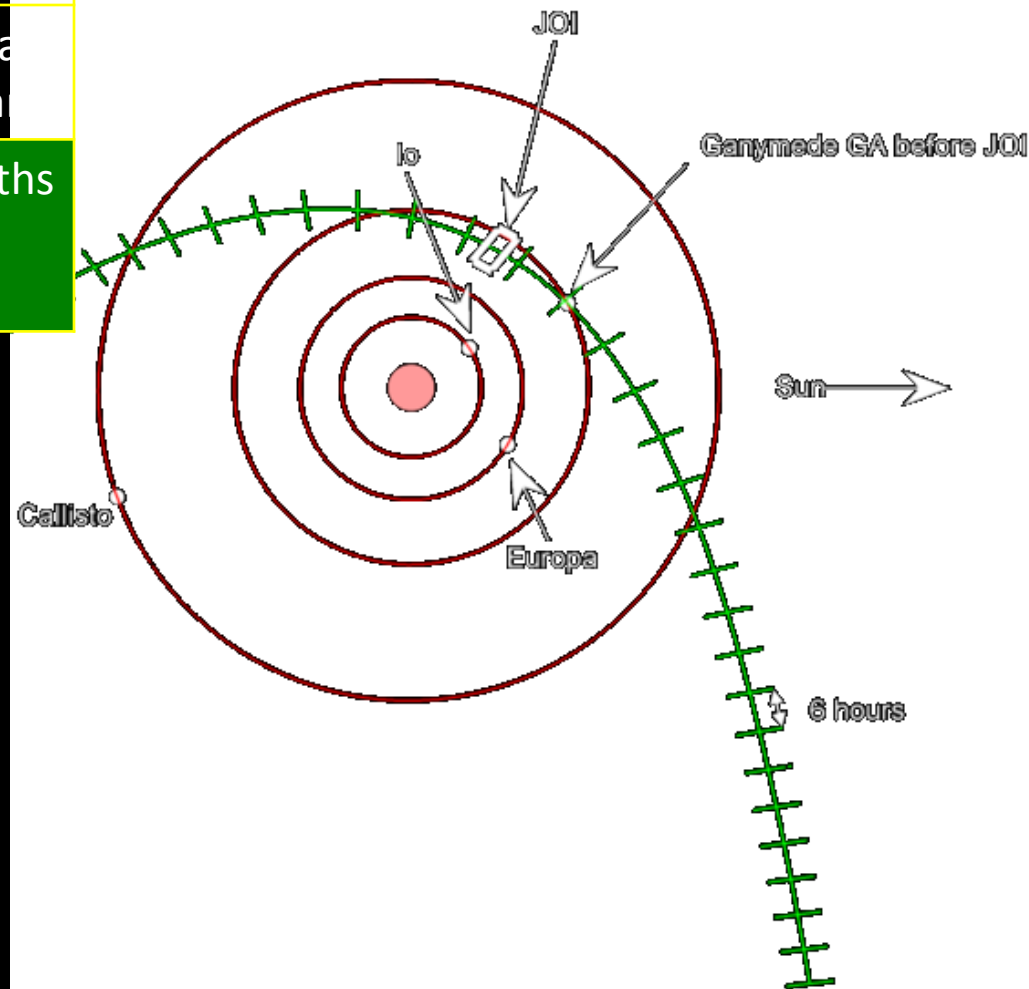
June 2022  
(August 2023)

Interplanetary transfer  
(Earth-Venus-Earth\_Earth)

7.6 years  
(8 years)

Jupiter orbit insertion and  
apocentre reduction with  
Ganymede gravity assists

11 months



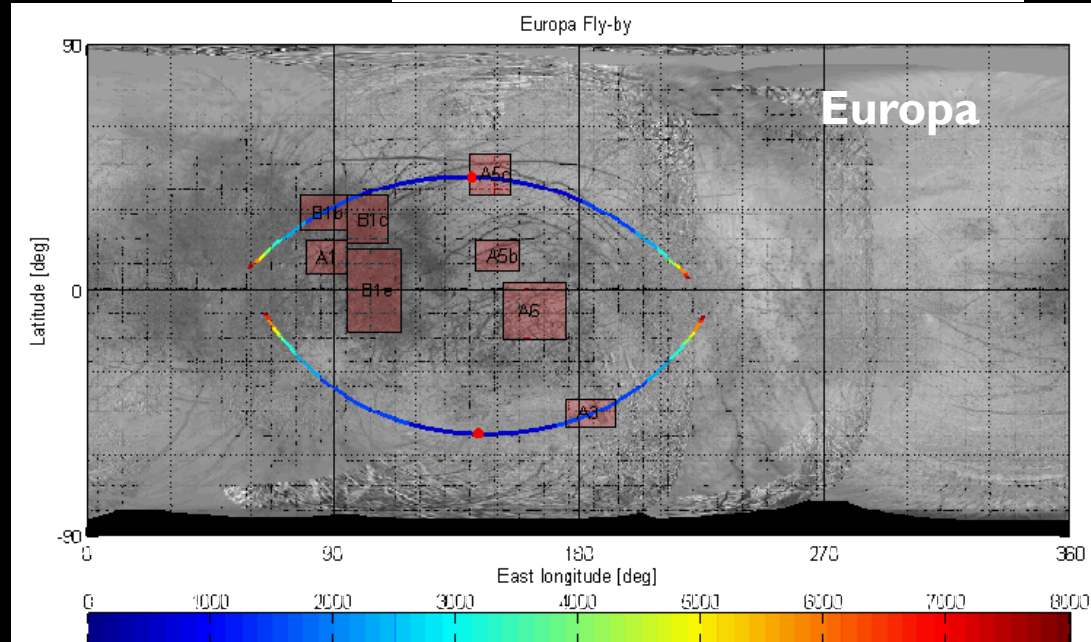
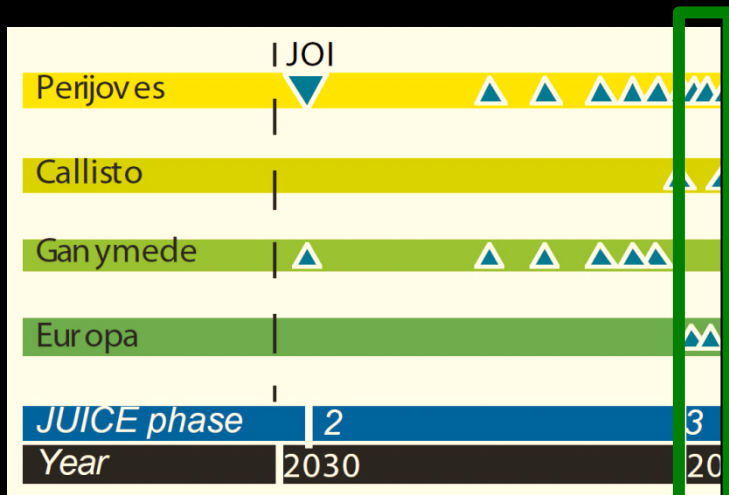
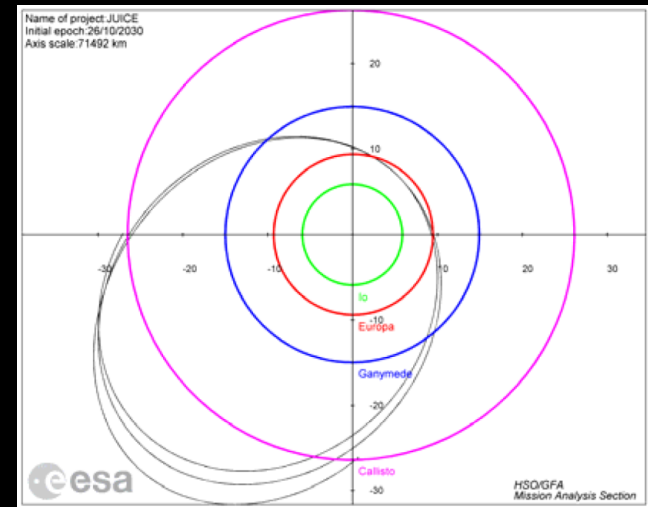
	JOI
Perijoves	▲▲▲▲▲
Callisto	
Ganymede	▲▲▲▲▲
Europa	
JUICE phase	2
Year	2030

## Spacecraft Design

## Definition Phase

## Mission phases

Launch	June 2022
Interplanetary transfer (Earth-Venus-Earth_Earth)	7.6 years
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2 Europa flybys	36 days



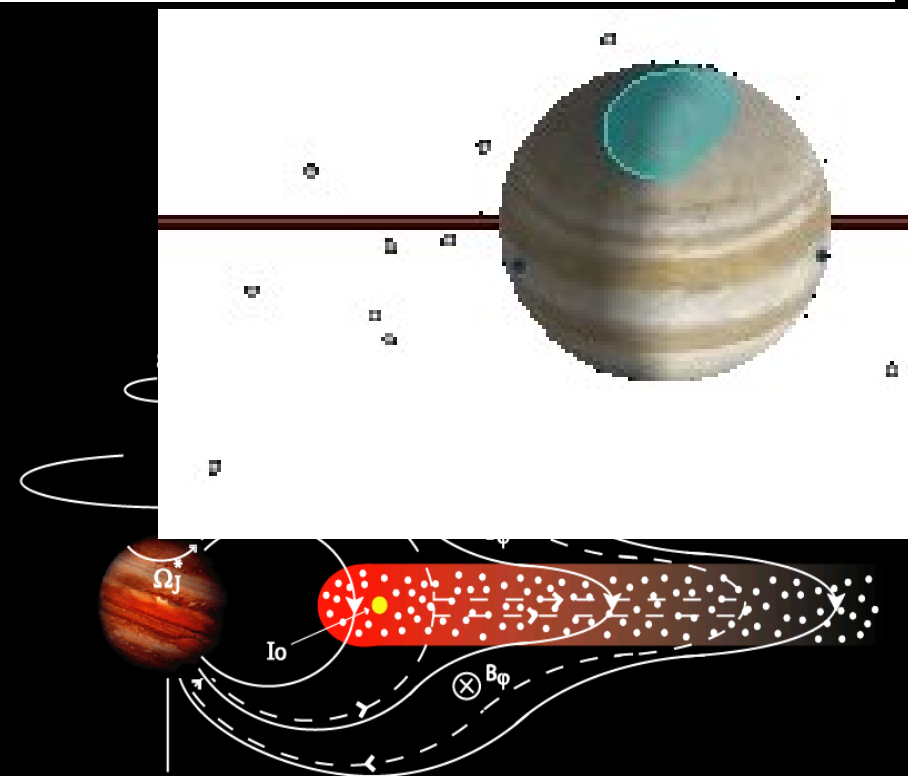
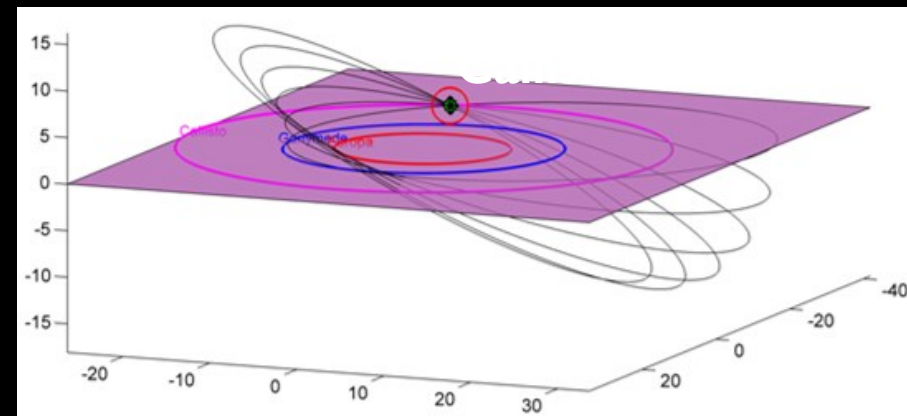
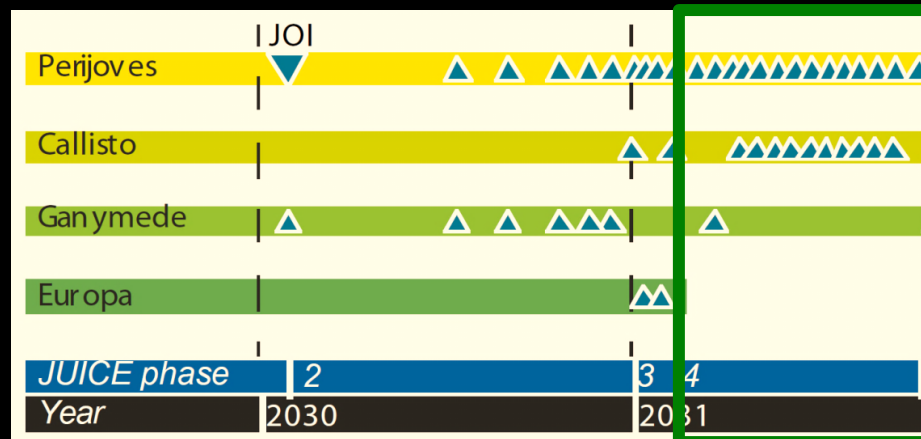


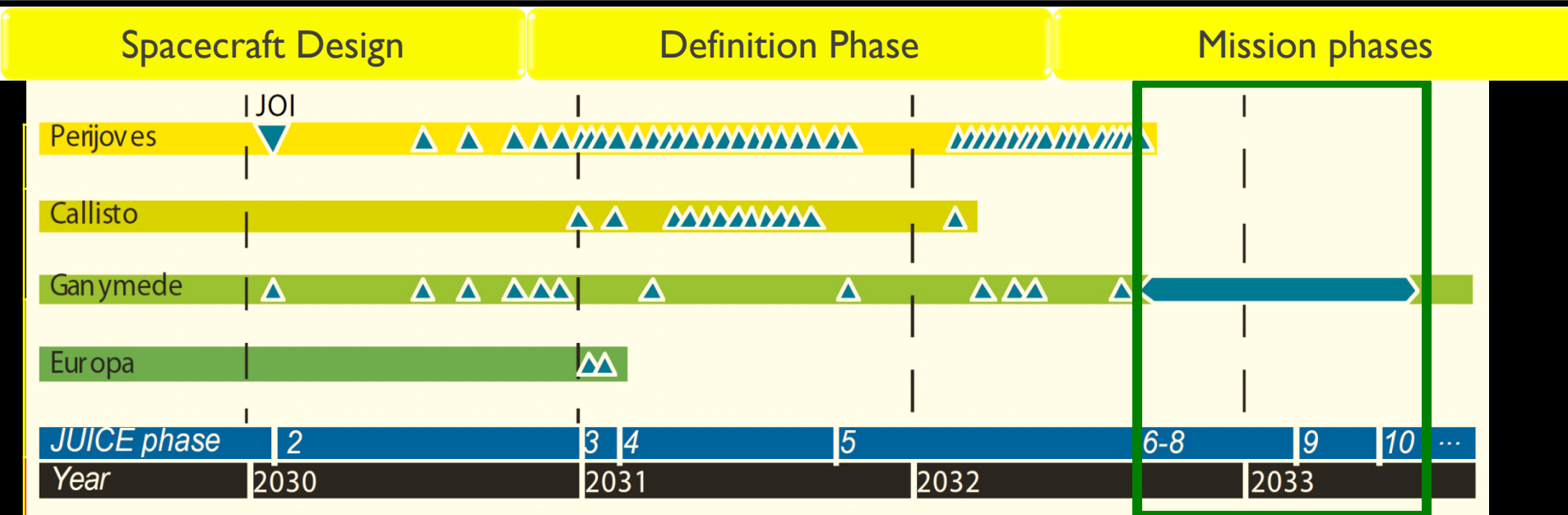
## Spacecraft Design

## Definition Phase

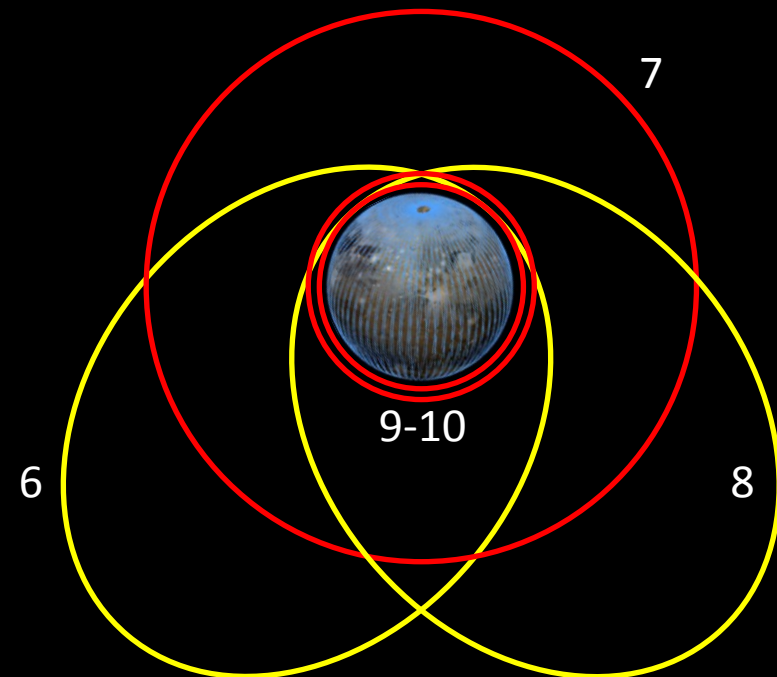
## Mission phases

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Reduction of $v_{inf}$ (Ganymede, Callisto)	60 days
Increase inclination with 10 Callisto gravity assists	200 days





Reduction of $v_{inf}$ (Ganymede, Callisto)	60 days
Increase inclination with 10 Callisto gravity assists	200 days
Callisto to Ganymede	11 months
Ganymede (polar)	
10,000x200 km & 5000 km	150 days
500 km circular	102 days
200 km circular	30 days
Total mission at Jupiter	3 years



## Three large icy moons to explore

### Ganymede

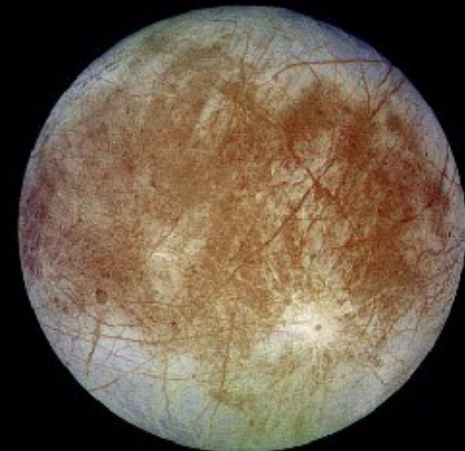
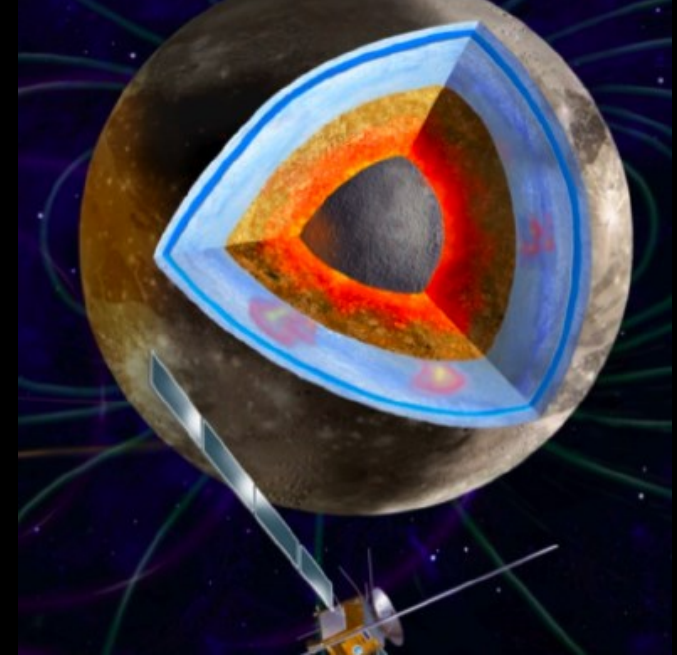
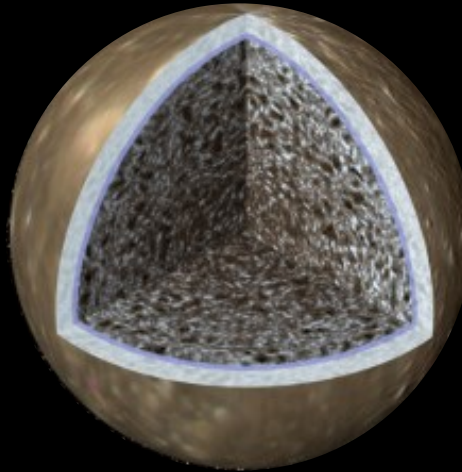
- Largest satellite in the solar system
- A deep ocean
- Internal dynamo and an induced magnetic field – unique
- Richest crater morphologies
- Archetype of waterworlds
- Best example of liquid environment trapped between icy layers

### Callisto

- Best place to study the impactor history
- Differentiation – still an enigma
- Only known example of non active but ocean-bearing world
- The witness of early ages

### Europa

- A deep ocean
- An active world?
- Best example of liquid environment in contact with silicates





# Exploration of the Jupiter system

JUICE

The biggest planet, the biggest magnetosphere and a mini solar system

## Jupiter

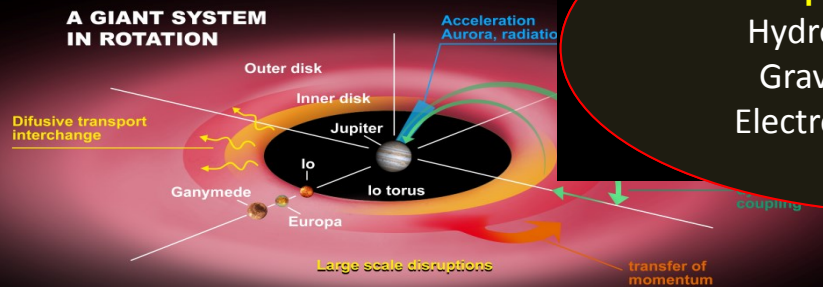
- Archetype for giant planets
- Natural planetary-scale laboratory for fundamental fluid dynamics, chemistry, meteorology,...
- Window into the formational history of our planetary system

## Magnetosphere

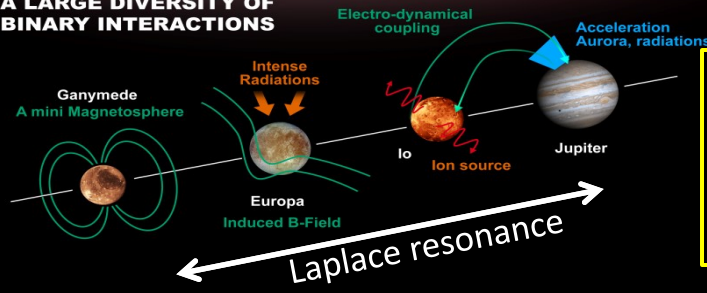
Largest object in our Solar System  
Biggest particle accelerator in the Solar System  
Unveil global dynamics of an astrophysical object

## Coupling processes

Hydrodynamic coupling  
Gravitational coupling  
Electromagnetic coupling



## A LARGE DIVERSITY OF BINARY INTERACTIONS



## Satellite system

- Tidal forces: Laplace resonance
- Electromagnetic interactions to magnetosphere and upper atmosphere of Jupiter

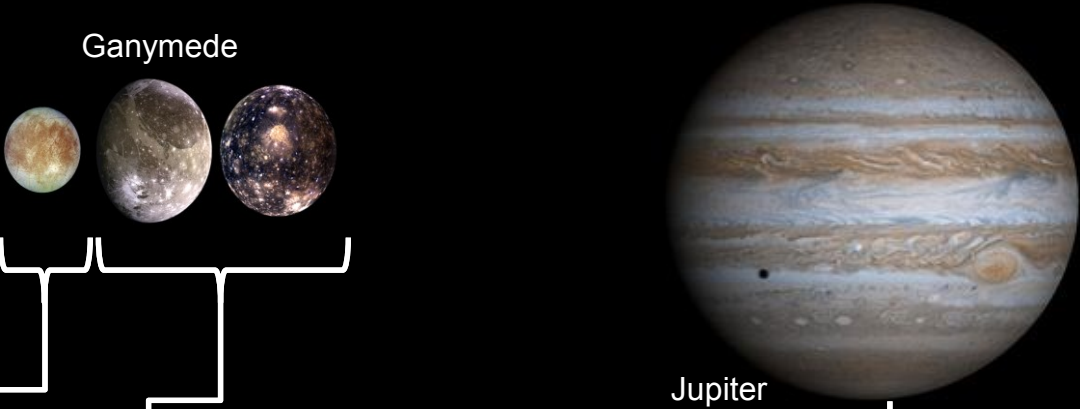
Waterworlds and giant planets

Habitable worlds

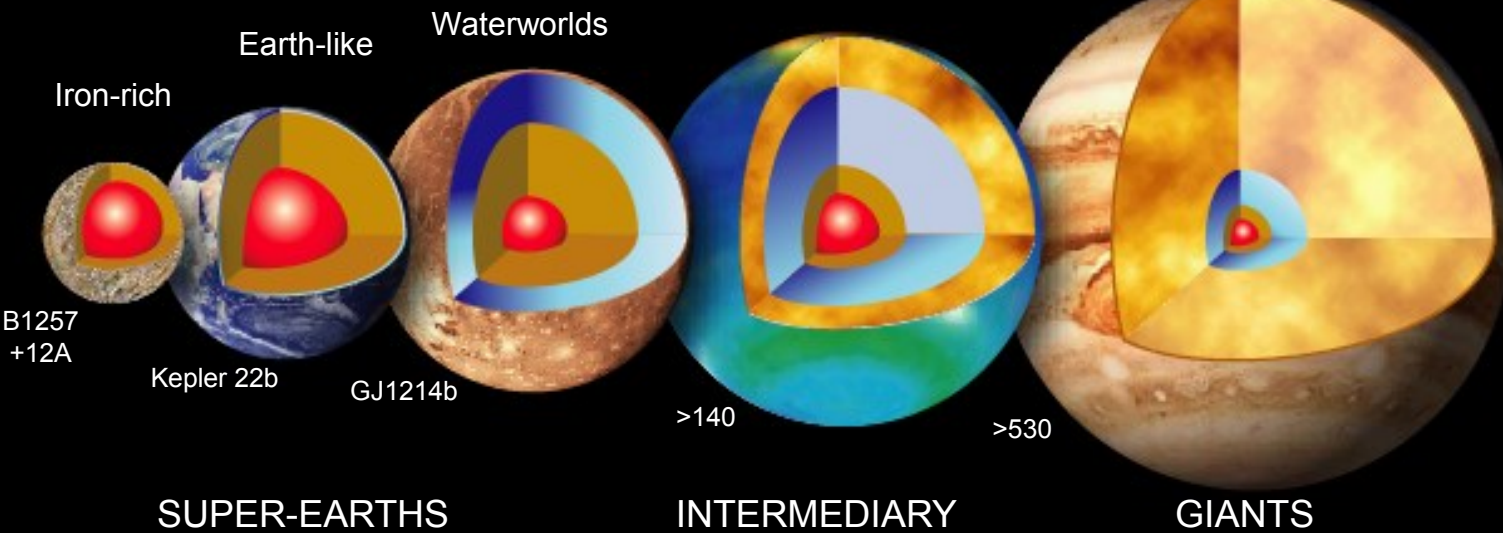
Astrophysics Connection

At Ganymede, JUICE will characterise an entire family of exoplanets: the waterworlds.  
At Jupiter, JUICE will further explore an archetype for giant exoplanets.

Jupiter system  
Three waterworlds  
One giant planet



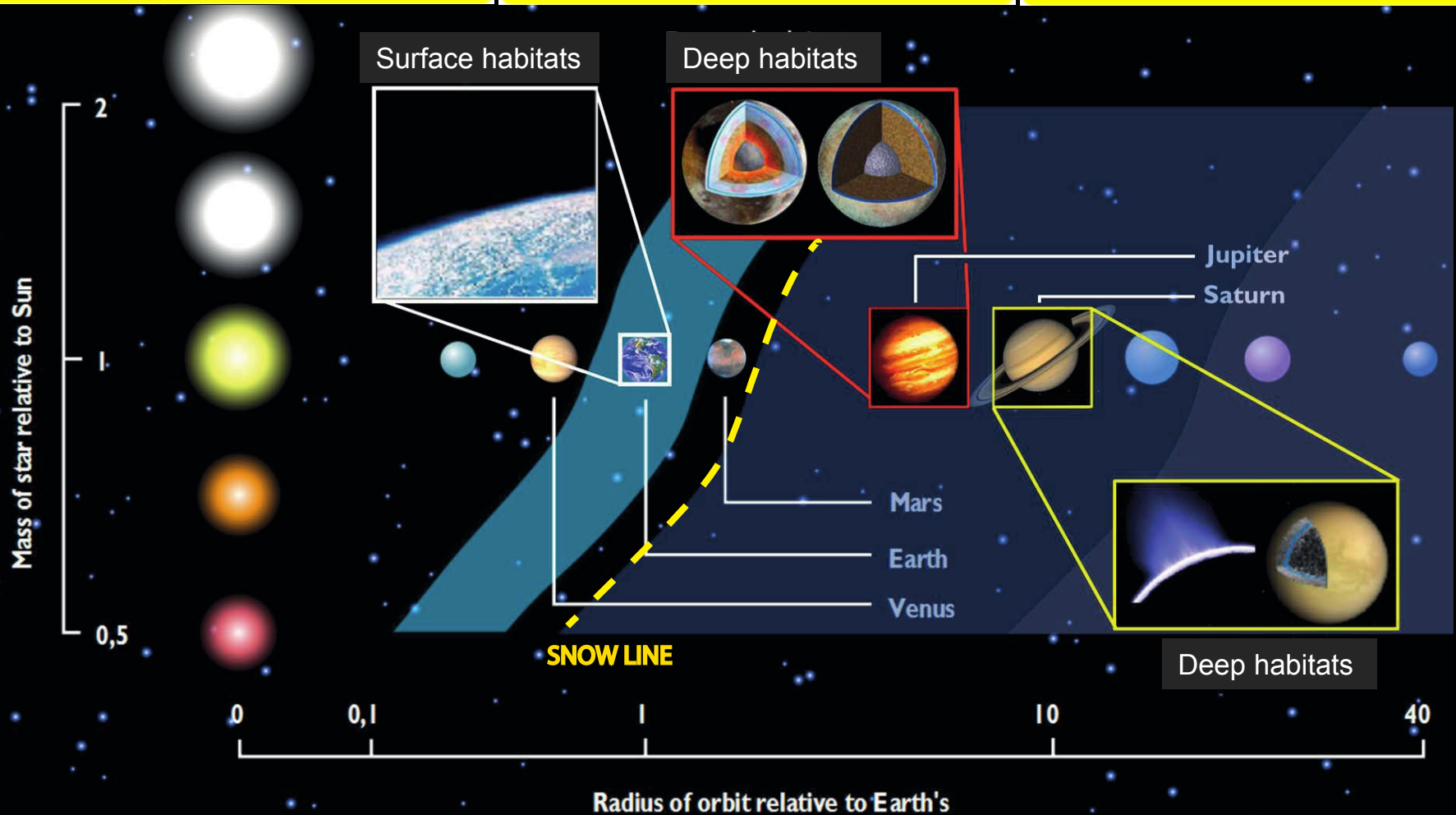
Exoplanets  
Five families  
> 800 planets



## Waterworlds and giant planets

## Habitable worlds

## Astrophysics Connection



Cosmic Vision: The quest for evidence of life in the Solar System must begin with an understanding of what makes a planet habitable

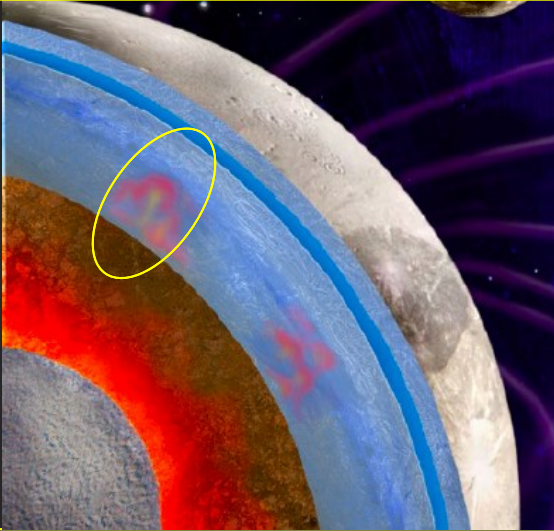
Ganymede and Europa are the archetypes of two classes of habitable worlds

## Waterworlds and giant planets

## Habitable worlds

## Astrophysics Connection

**Waterworlds:** If habitable, the liquid layers are trapped between two icy layers



### Occurrence:

Largest moons, hot ice giants, ocean-planets...  
Most common habitat in the universe ?

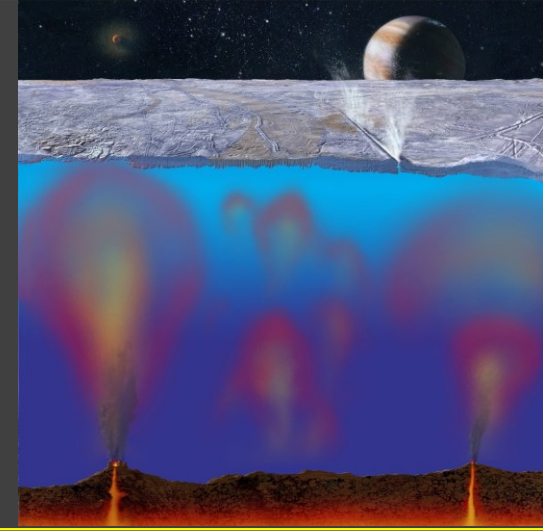
### Key question:

Are these waterworlds habitable ?

### What JUICE will do:

Via characterisation of Ganymede, will constrain the likelihood of habitability in the universe

**Europa-like:** If habitable, the liquid layers may be in contact with silicates as on Earth



### Occurrence:

Europa, Enceladus  
Only possible for very small bodies

### Key question:

How are the surface active areas related to potential deep habitats?

### What JUICE will do:

Pave the way for future landing on Europa  
Better understand the likelihood of deep local habitats



Waterworlds and giant planets

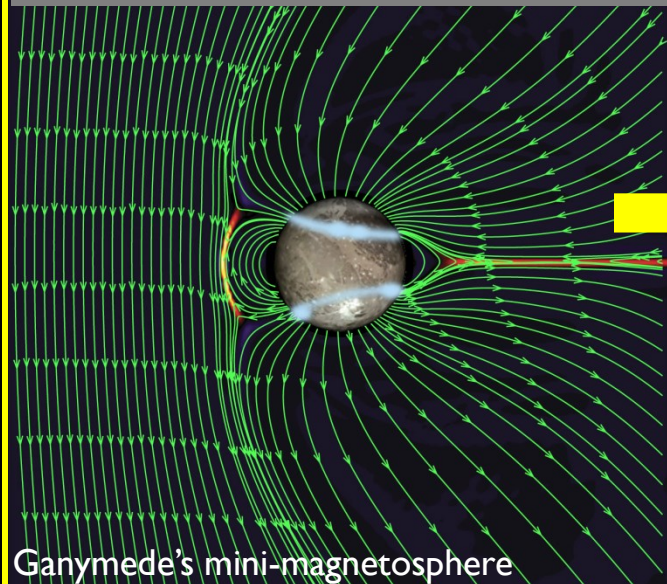
Habitable worlds

Astrophysics Connection

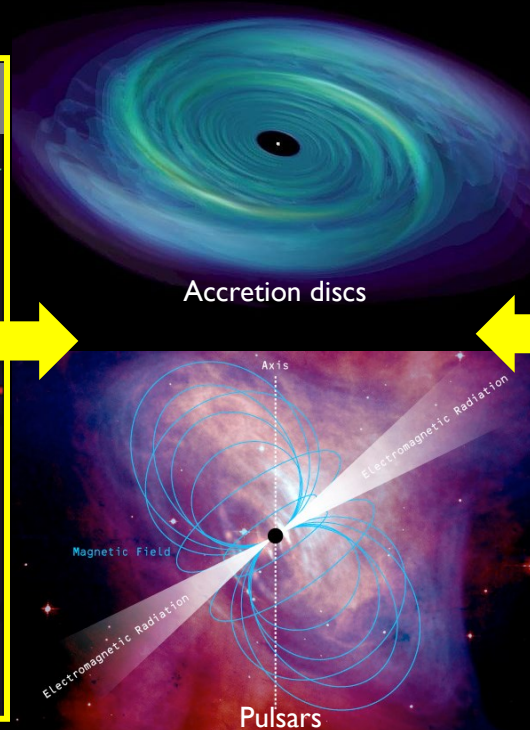
Most of the ordinary (baryonic) matter in the universe is a plasma, controlled by the fundamental electromagnetic force. It makes the Sun and stars, influences the environments of the Earth and other planets, and pervades the solar system, galaxies, and inter-galactic space.

What are the fundamental processes that transport, convert, and release energy in plasmas?

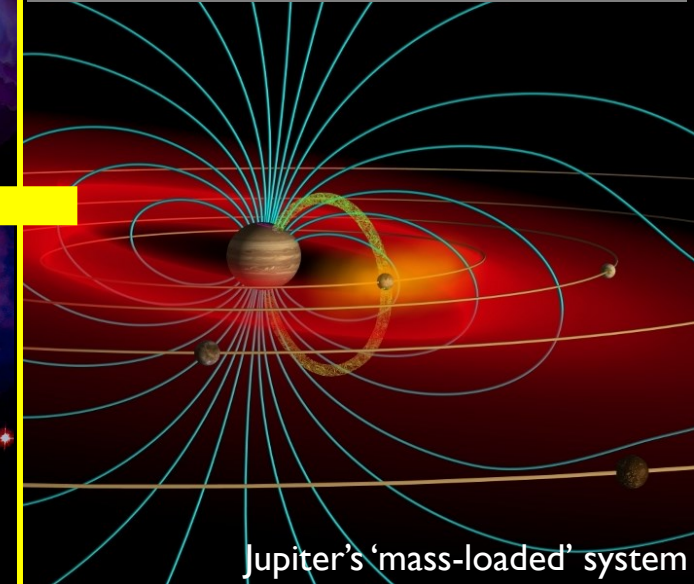
Magnetic reconnection



Accretion discs



Jupiter's spinning magnetodisc





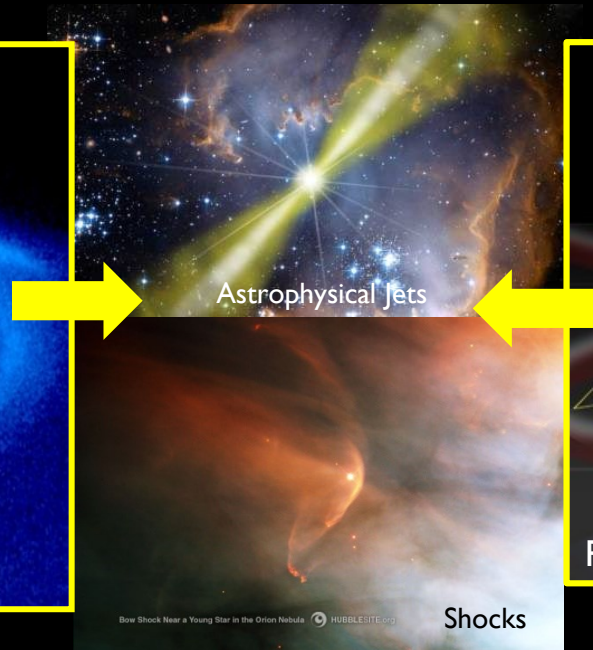
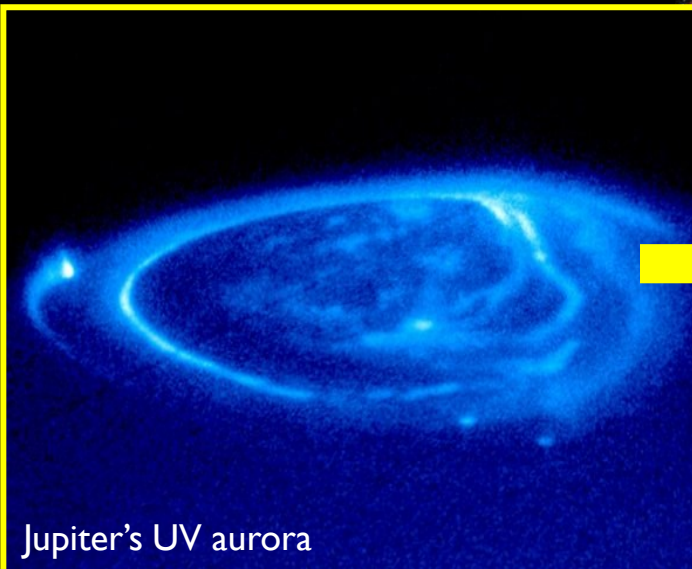
Waterworlds and giant planets

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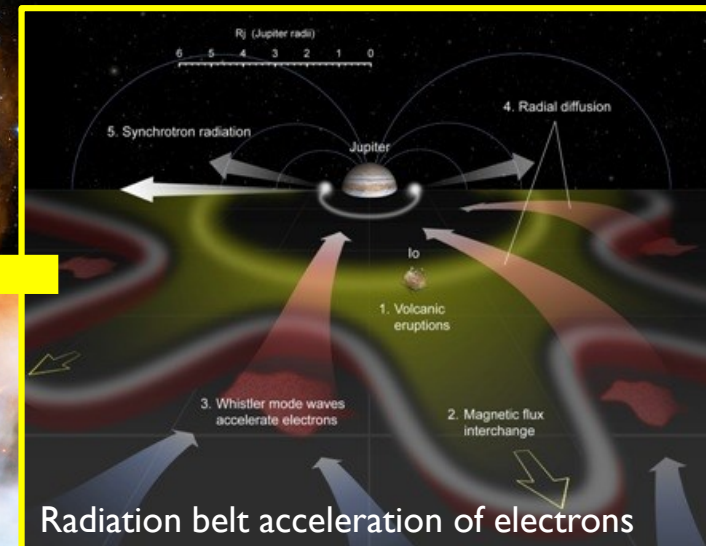
Astrophysics Connection

## How and where are particles accelerated in nature?

### Auroral processes



### Jovian radiation environment



Without understanding plasmas our knowledge of the universe is simply incomplete.  
The best place to study these processes in detail is in the Jovian system.

# Conclusions

JUICE

Internat. Interest

The Firsts

Cosmic Vision

Impact

Timeliness

Time to progress from exploration to characterisation of habitable worlds

