

Panel C / Chapter 4

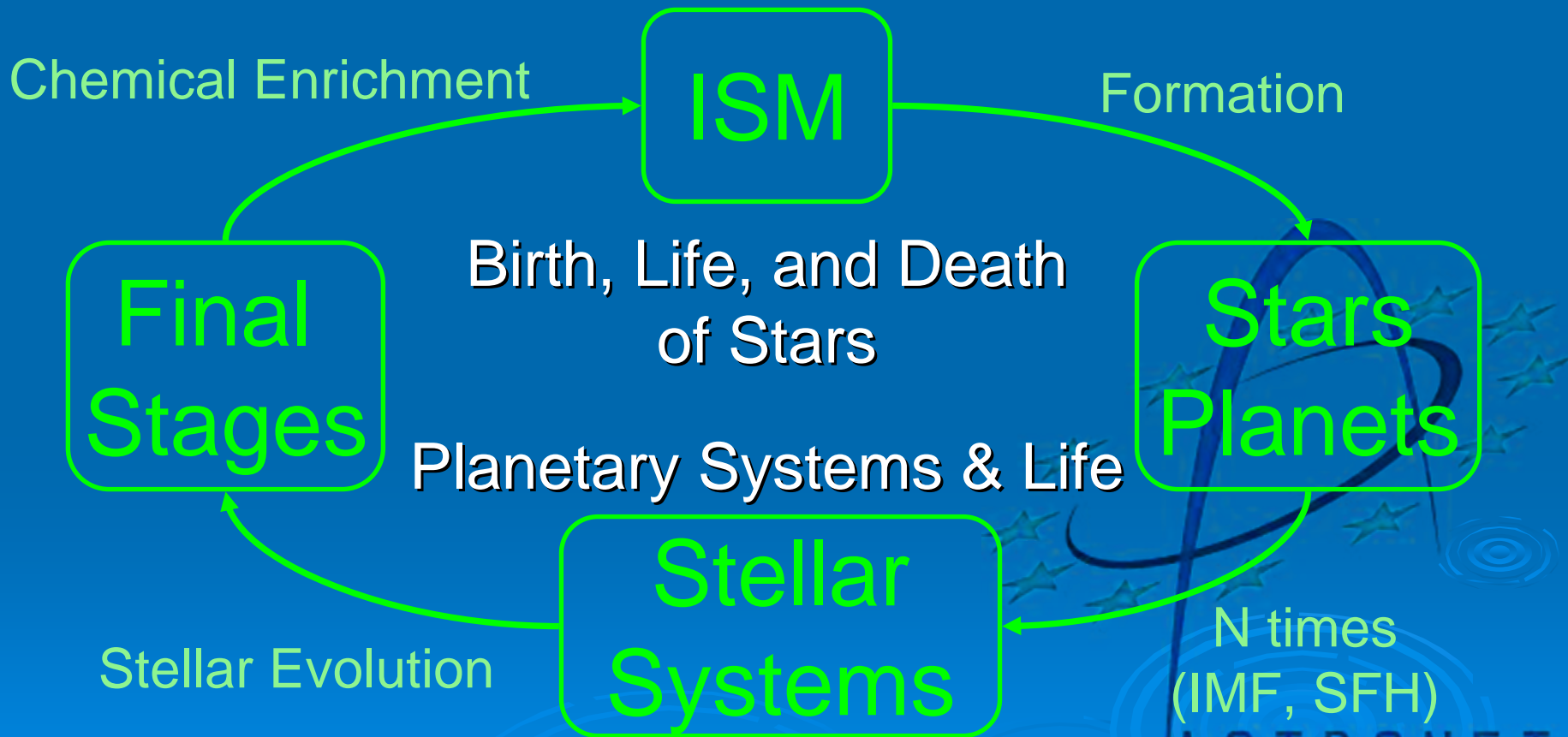
What is the origin and evolution of stars and planets?

23 January 2007

- Science Questions
- Recommendations
- Input from the Community

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Ewine van Dishoeck, Stephane Guilloteau, Pavel Kroupa, Didier
Queloz, Massimo Turatto, Christoeffel Walkens

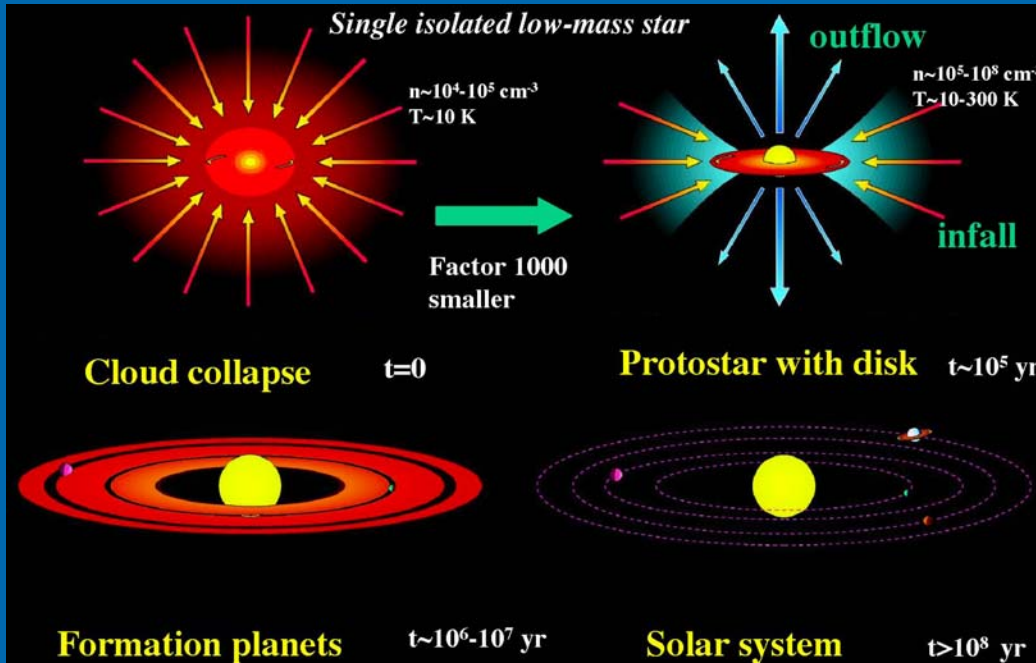
What is the origin and evolution of stars and planets?



Science Questions

- How do stars form?
- Is the Initial Mass Function of stars universal?
- What can we learn probing stellar interiors?
- What is the life-cycle of the ISM and stars?
- How do planetary systems form and evolve?
- What are the demographics of planets in the Galaxy?
- How do we tell which planets harbour life?

How do stars form?



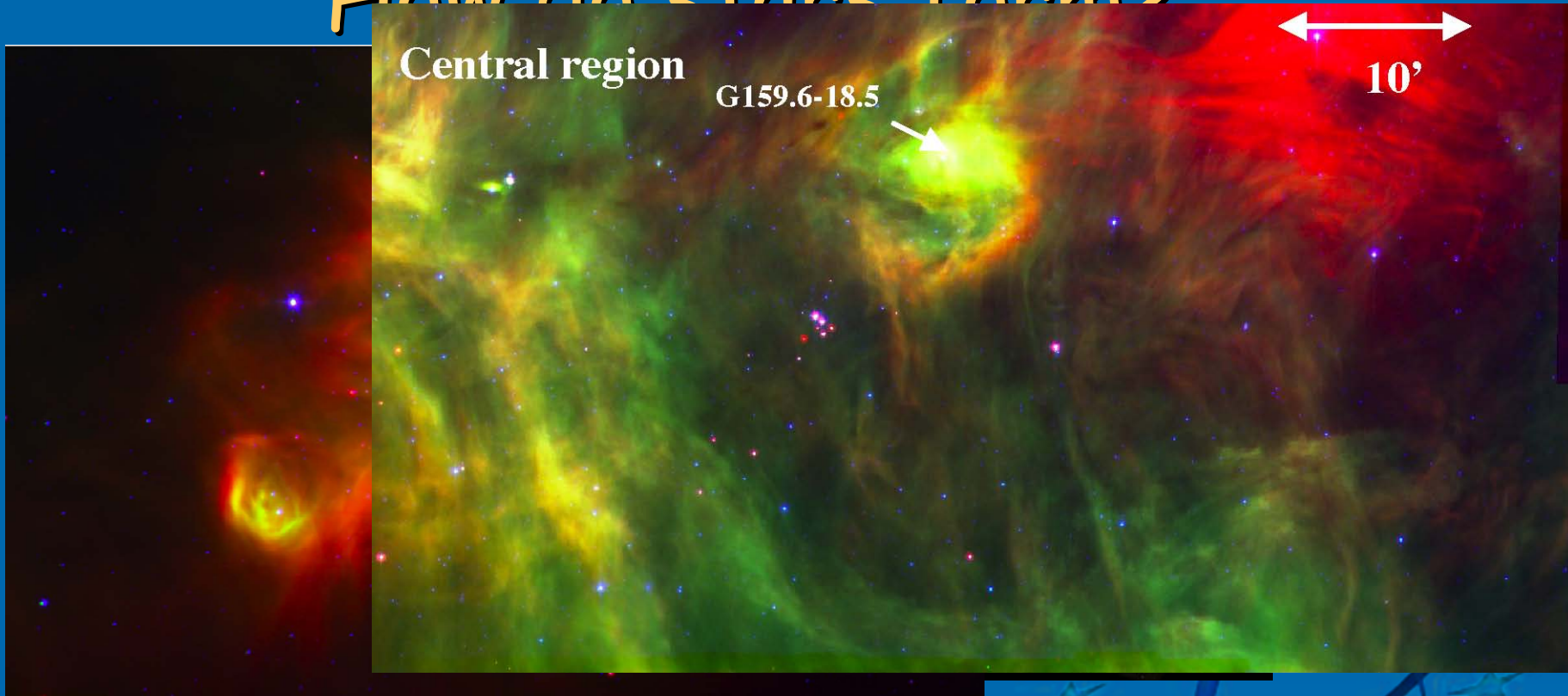
- The complexity of star formation: microphysics, feedback; magnetic fields, turbulence
- The modes of star formation: quasi-static vs. dynamic, clusters
- Low metallicity star formation and primordial star formation

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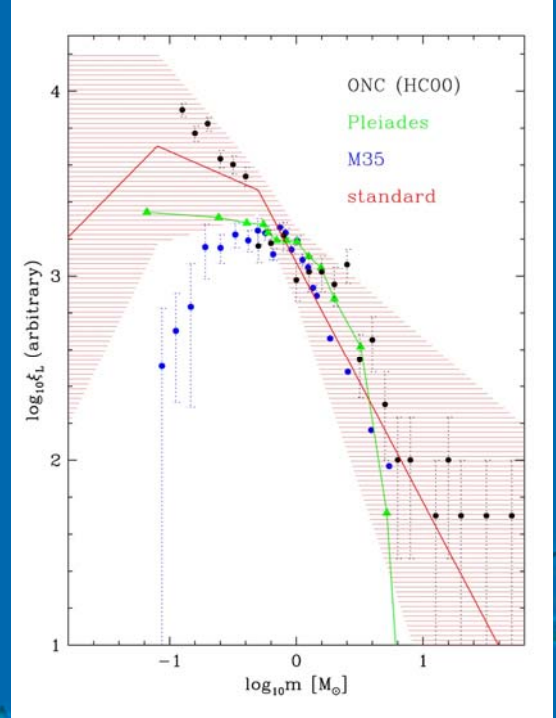
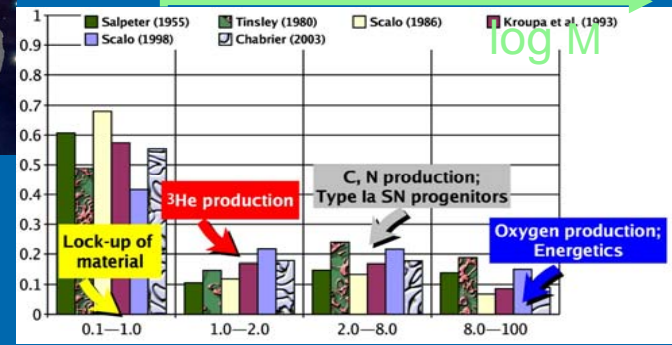
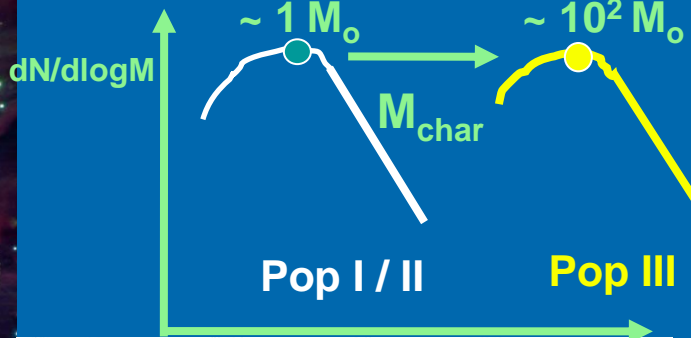
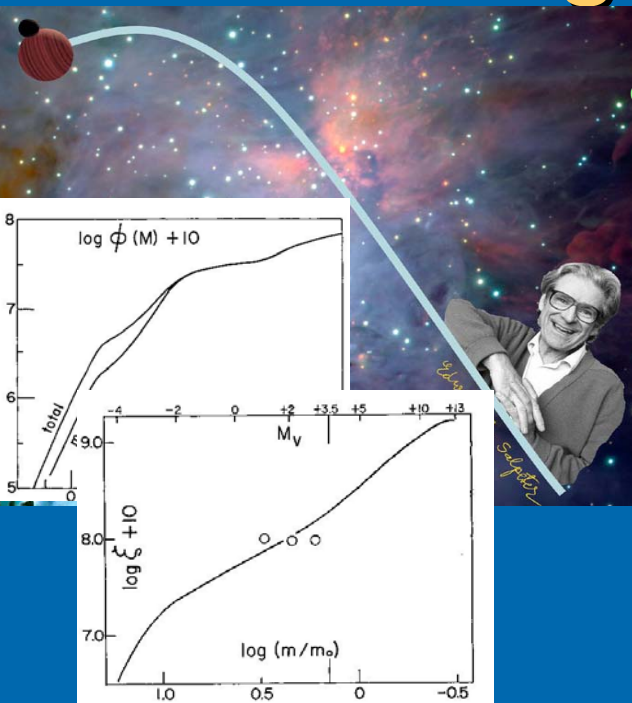
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How do stars form?



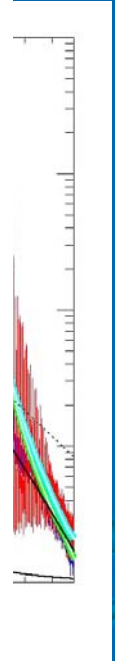
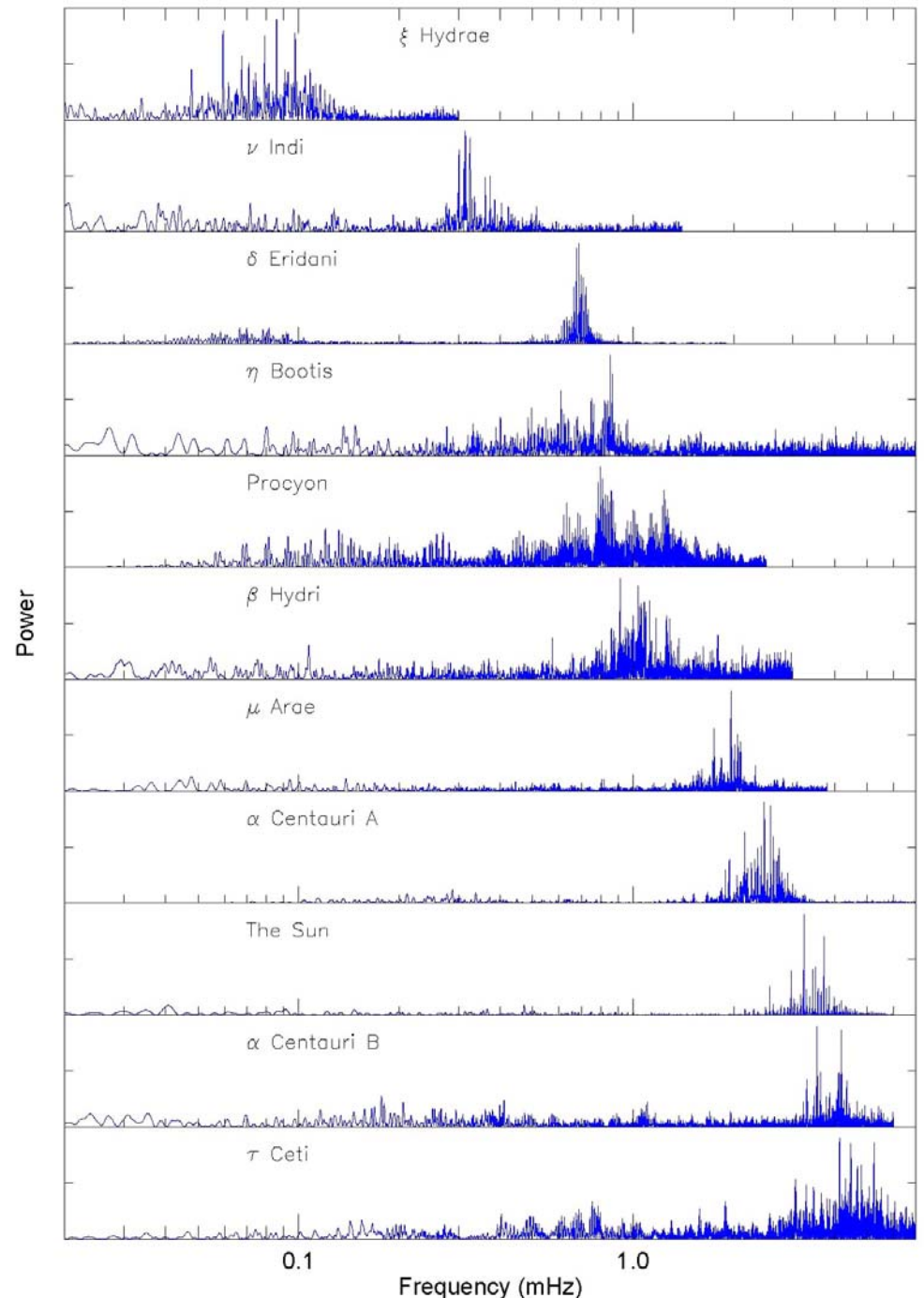
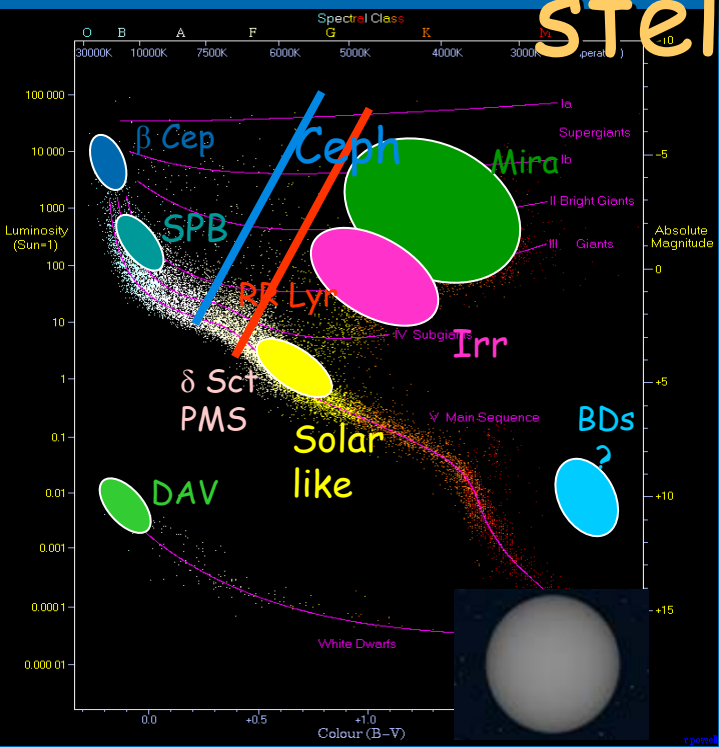
- The role of clusters: dynamical evolution => demanding computations, evolution of binaries, impact on planet formation
- High angular resolution observations => resolve dense clusters, understand the structure of protoclusters, extragalactic super star clusters

Is the initial mass function of stars universal?



- (Non-)Universality of the stellar IMF; primordial (Pop III) IMF
- Origin of the IMF (feedback vs. imprinting)
- The IMF as a global product of Star Formation across the Universe and its implication on the evolution of the Universe

What do we know about stellar interiors?

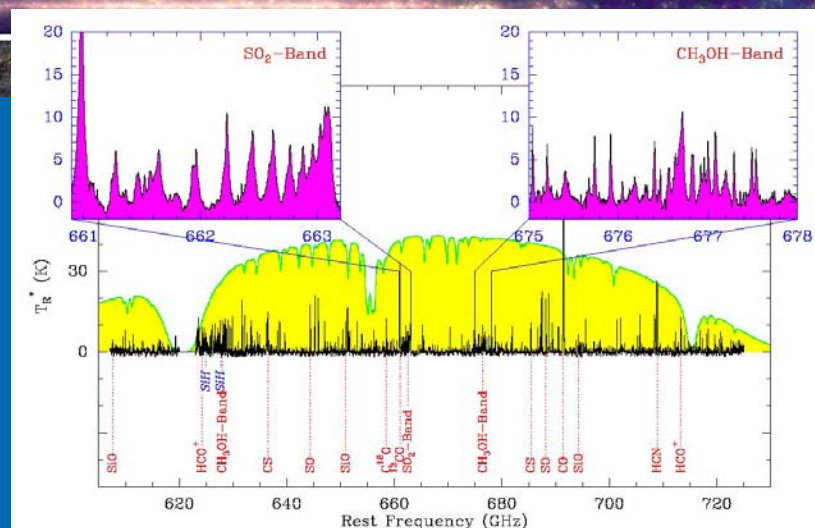
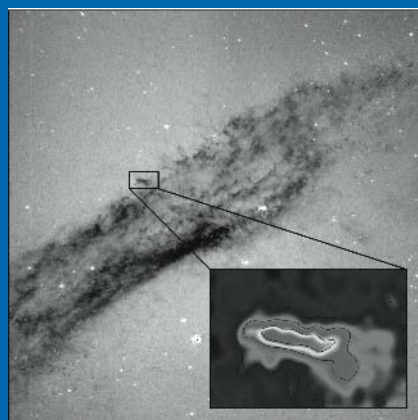
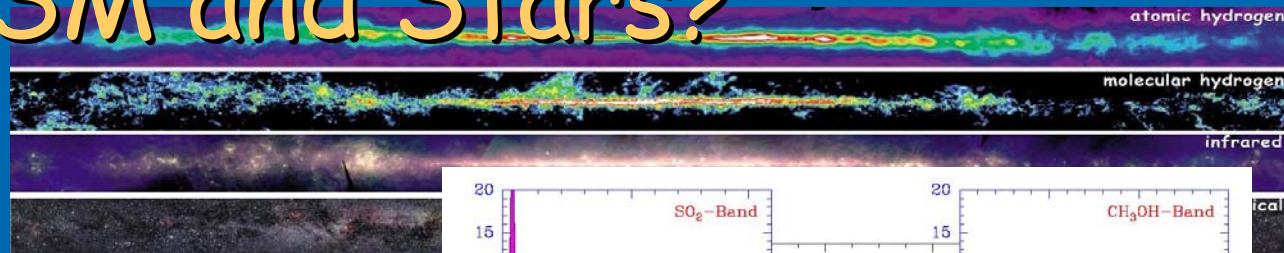
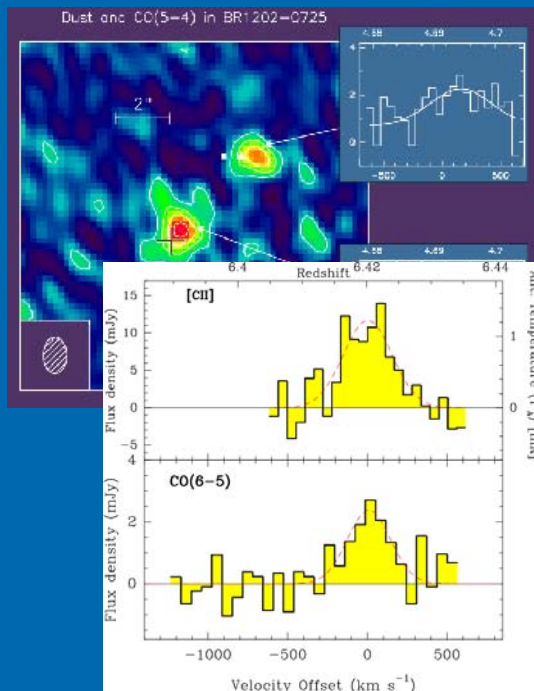


- Asteroseismology as a probe of stellar interiors
- Interior Physics: structure, nuclear reactions
- Stellar atmospheres: activity, magnetic fields

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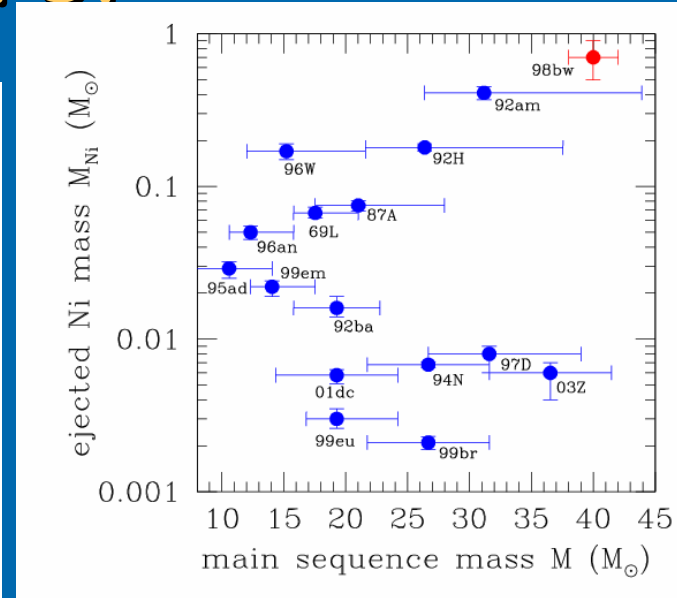
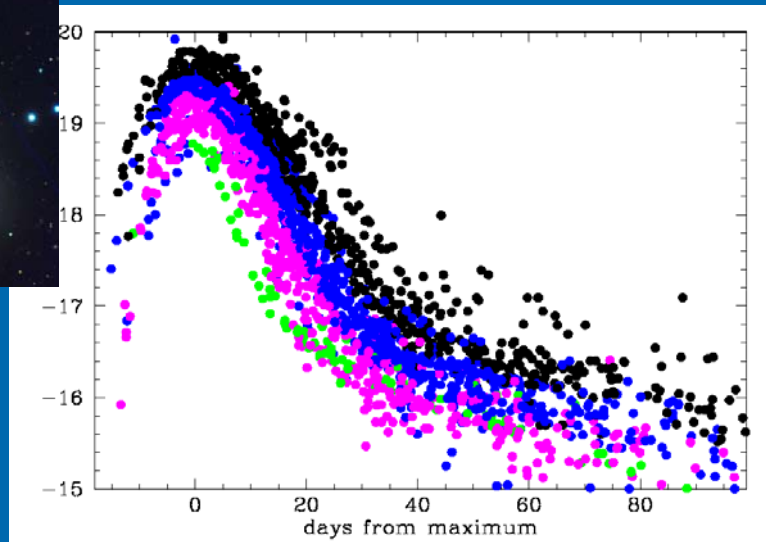
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What is the life-cycle of the ISM and Stars?



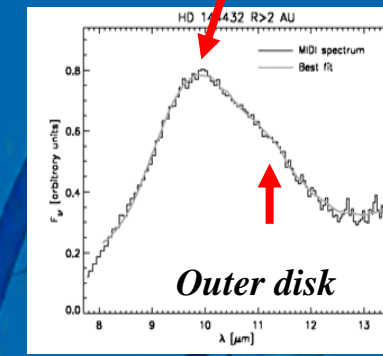
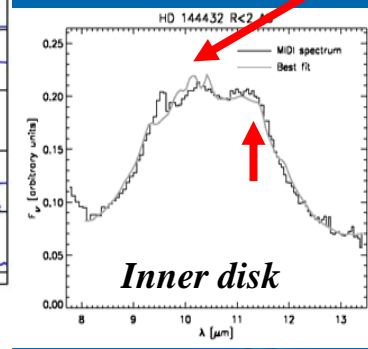
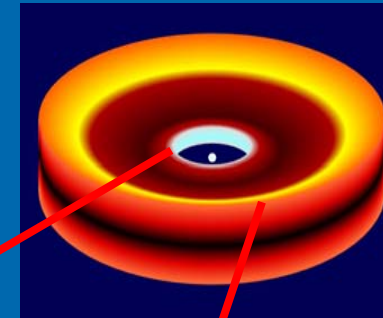
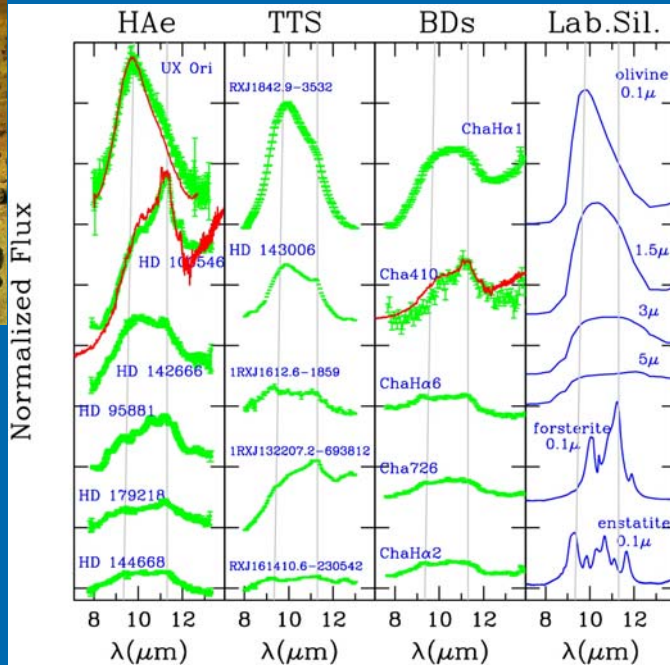
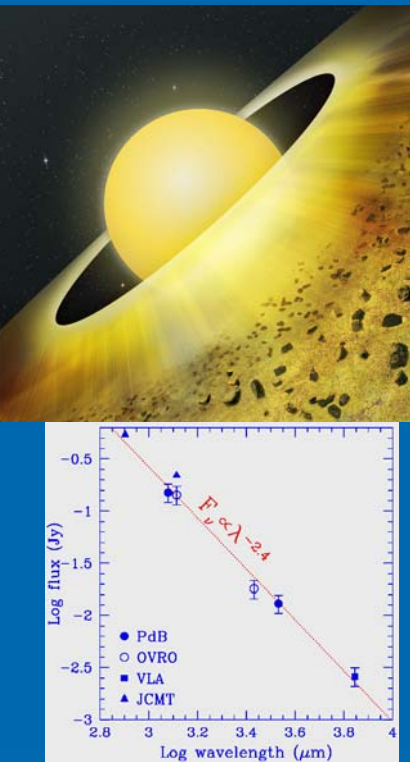
- Detection and characterization of the ISM at high redshift, in “normal” non-lensed galaxies => Chemical evolution of the ISM in the Universe
- Chemistry of the local ISM and connection with Solar System bodies, Astrobiology, Laboratory studies

What is the life-cycle of the ISM and Stars?



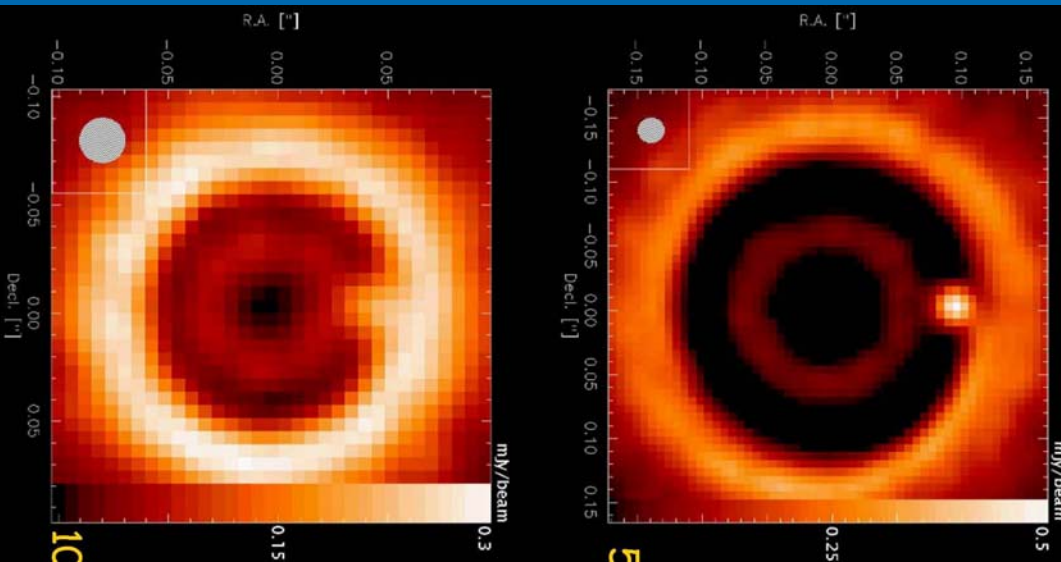
- Supernova/hypernova progenitors, explosion physics
- Understand SN Ia and CC SNe diversity and the possible cosmological evolution
- Yields and mass loss history of SNe, PNe, ...

How do planetary systems form and evolve?



- Disks structure and evolution \Rightarrow Planets formation
- Dust evolution from ISM grains to pebbles and planetesimals
- Chemical evolution of the molecular gas

How do planetary systems form and evolve?



QuickTime™ and a Cinepak decompressor are needed to see this picture.

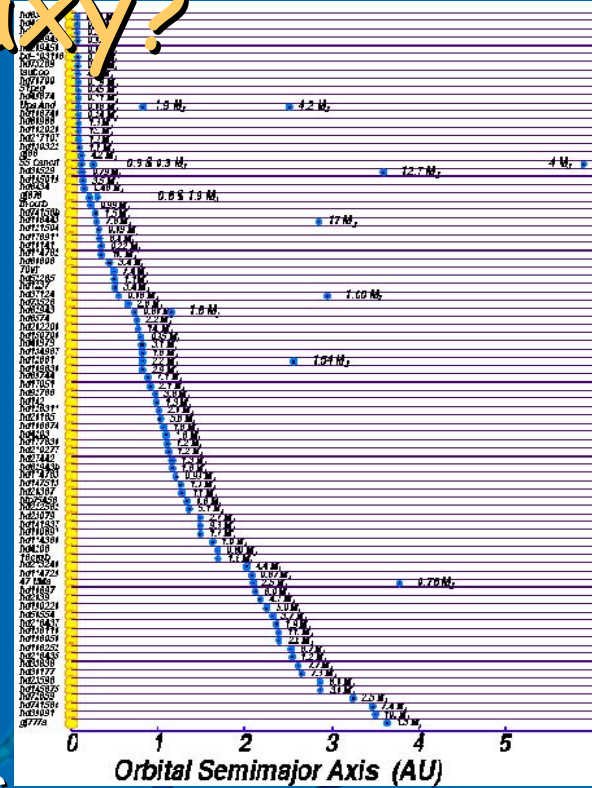
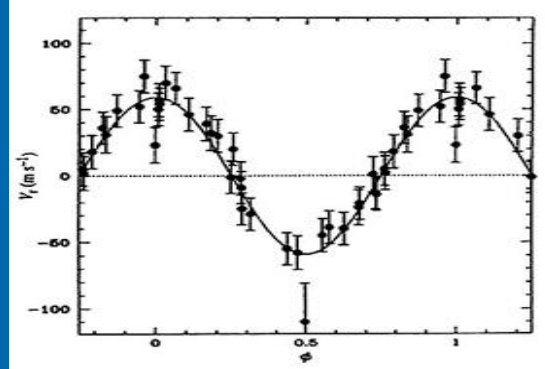
- Direct detection of forming planetary systems
- Are Planetary systems a common output of star formation?
- Is our own Solar System a common product of the planetary formation process?

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What are the demographics of planets in the Galaxy?



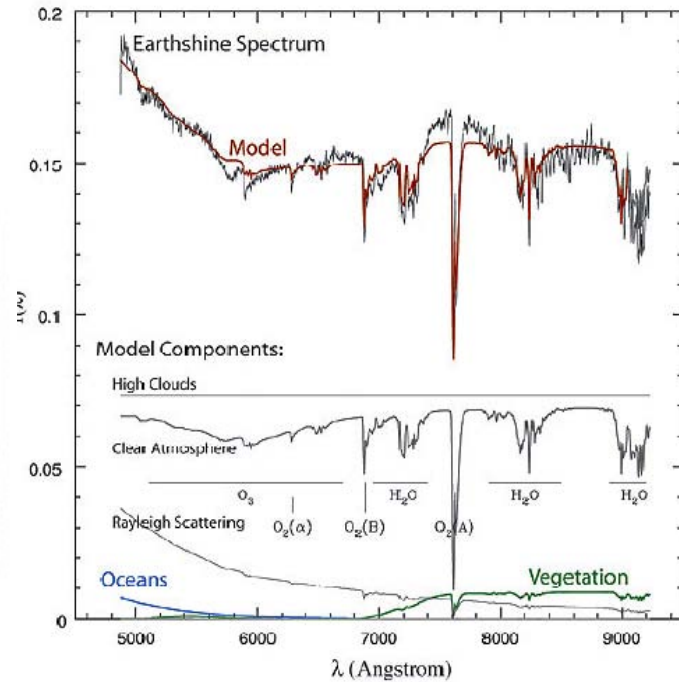
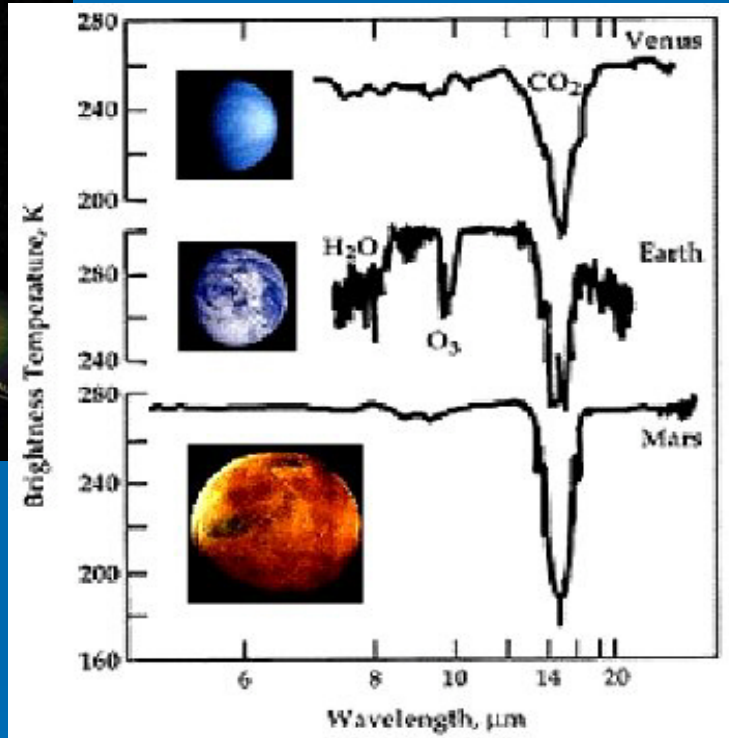
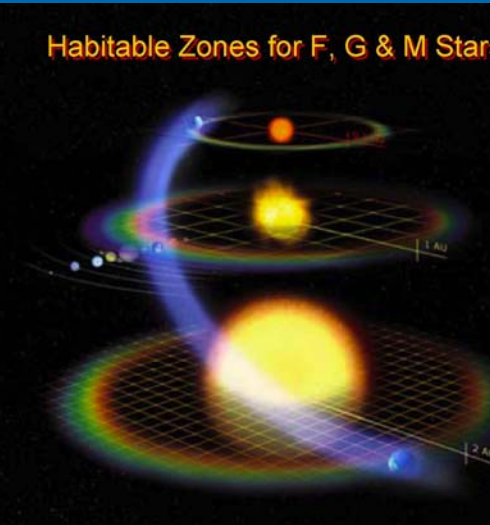
- Expand statistics, search for “wide” Jupiters
- Are Planetary systems a common output of star formation?
- Is our own Solar System a common product of the planetary formation process?

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How do we tell which planets harbour life?

Habitable Zones for F, G & M Stars



- Search for terrestrial planets in habitable zone
- Characterization of planetary atmospheres and search for life-supporting and life-byproduct molecules

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Recommendations

General

- Essential role of theory
 - Dedicated machines and development of mathematical tools for dynamical evolution computations
 - From microscopic to macroscopic processes in Star Formation
 - Stellar evolution and structure models
 - Planetary systems formation and evolution
- Laboratory studies
 - Astrobiology
 - Complex molecules and solids, obs. benchmarks

Recommendations

Requirements for principal facilities

- Near infrared imaging and spectroscopy at high angular resolution => Fully AO ELT
- Near- to Far-IR at very high spatial resolution with high contrast => IR interferometry in space
- High angular resolution and sensitivity in the mm and radio for continuum and spectroscopy => main facility ALMA and possibly SKA
- Long term continuous monitoring with high accuracy => dedicated space platform
- High accuracy radial velocity experiments from the ground
- High accuracy astrometry from ground or space

Recommendations

Requirements for secondary facilities

- Measurements of velocity and magnetic fields on a broad range of scales => sensitive mm/radio large single dish telescopes and interferometers
- Wide field diffraction limited imaging and multi object spectroscopy with current generation of large telescopes
- Full exploitation of ALMA/SKA critically depend on the availability of large single dish and VLBI
- Asteroseismology and exoplanets transits will benefit from coordinated programmes on telescope networks
- Availability of X-ray observatories for deep/large area surveys and spectroscopy of individual objects

Input from the community

- Stellar Astrophysics
 - P. Diamond: Life-cycle of stars
 - I. Pagano: Issues in stellar astrophysics
 - D. Lennon: Exploiting stellar surveys, spectroscopy
 - G. Tautvaisiene: Interpretation of stellar spectra
 - Th. Appurchaux: Asteroseismology
 - J. Surdej / A. Quirrenbach: Stellar astrophysics at high resolution
 - I. Pustyl'nik: peculiar binary systems
- Interstellar Medium
 - P. Sarre: Cosmic dust
- Exoplanetary Systems
 - J.-L. Beuzit: Direct detection of Exoplanets
 - J. Schneider: Earth-like planets and biomarkers