

Astrochemistry: a (very) brief introduction

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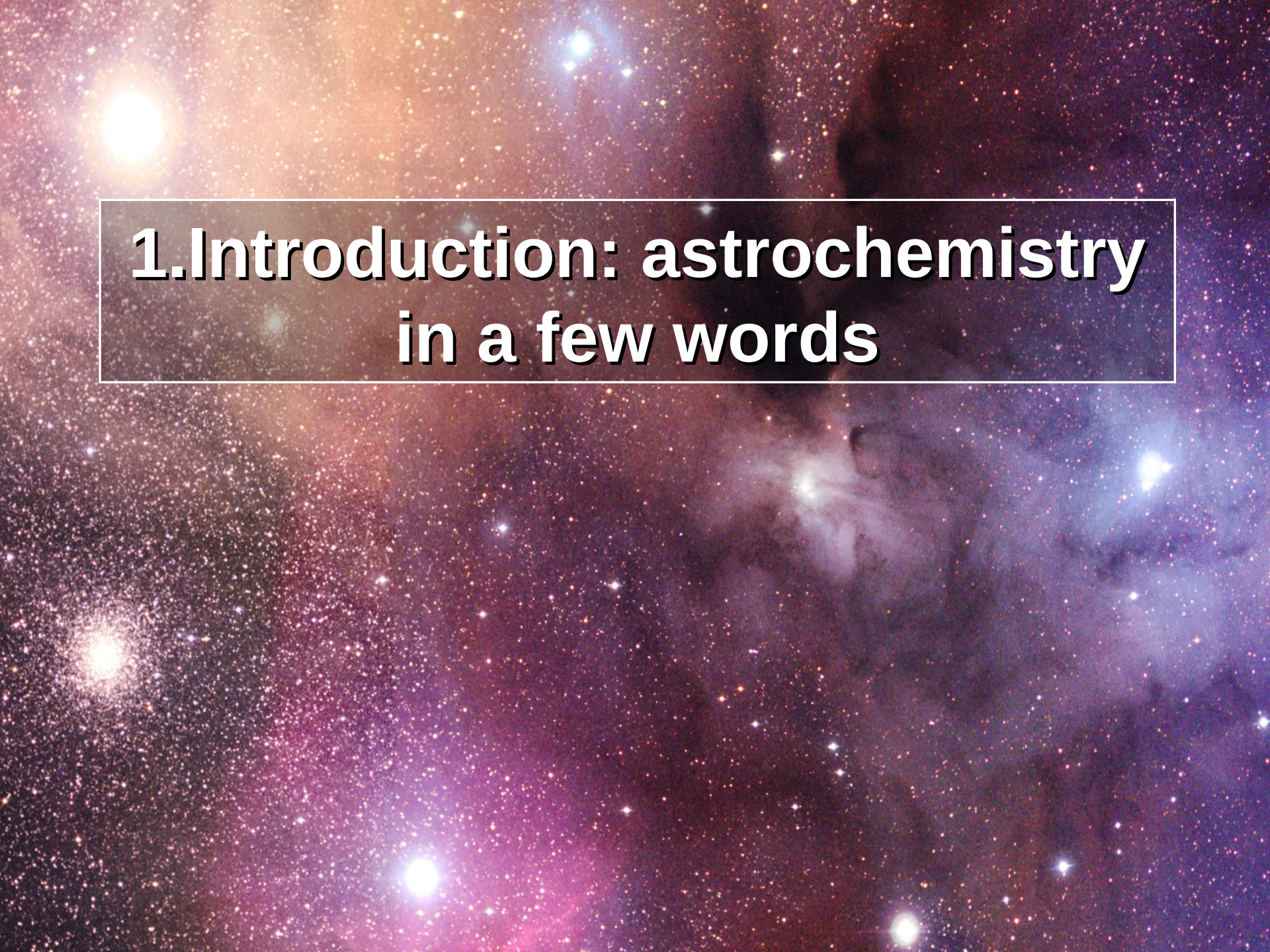
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(Belgium)

Astrochemistry: a (very) brief introduction

- 1. Introduction: astrochemistry in a few words**
- 2. Chemical processes in astronomical conditions**
- 3. What do we need to feed astrochemical studies?**

The background is a rich, multi-colored star field. It features a dense distribution of stars in various colors, including bright yellow and white, deep red, and cool blue. The stars are set against a dark, almost black background, which is punctuated by wisps of interstellar dust and gas in shades of purple, blue, and pink. The overall effect is that of a vast, colorful stellar population.

1. Introduction: astrochemistry in a few words

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It is difficult to admit the existence of molecules in interstellar space, because once a molecule is dissociated there seems to be no chance for the atoms to join together again.

– Arthur Stanley Eddington (1926)

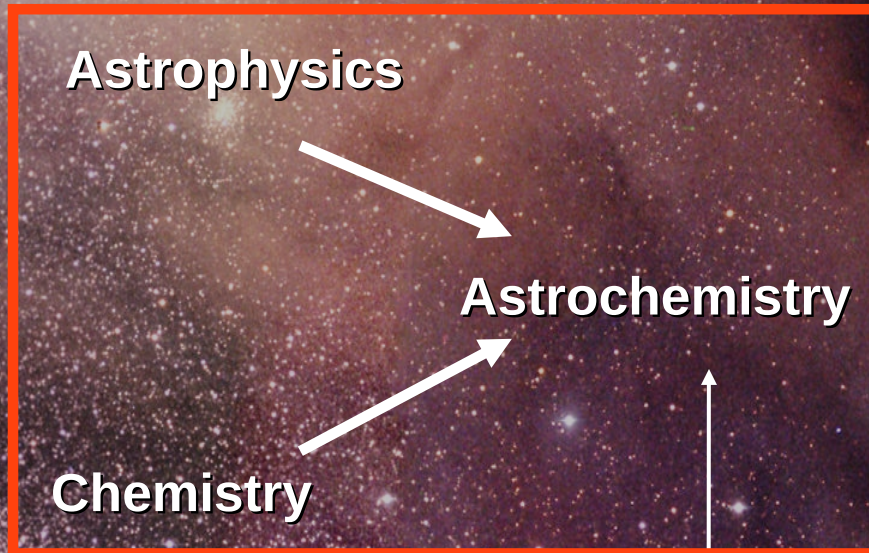
Chemical diversity and complexity:

- about 170 molecules identified in astronomical environments: including neutral species (1st identification: CH, Swings & Rosenfeld 1937), cationic species, anionic species (6 discovered quite recently)
- efficient processes are at work in space environments

The challenges of astrochemistry:

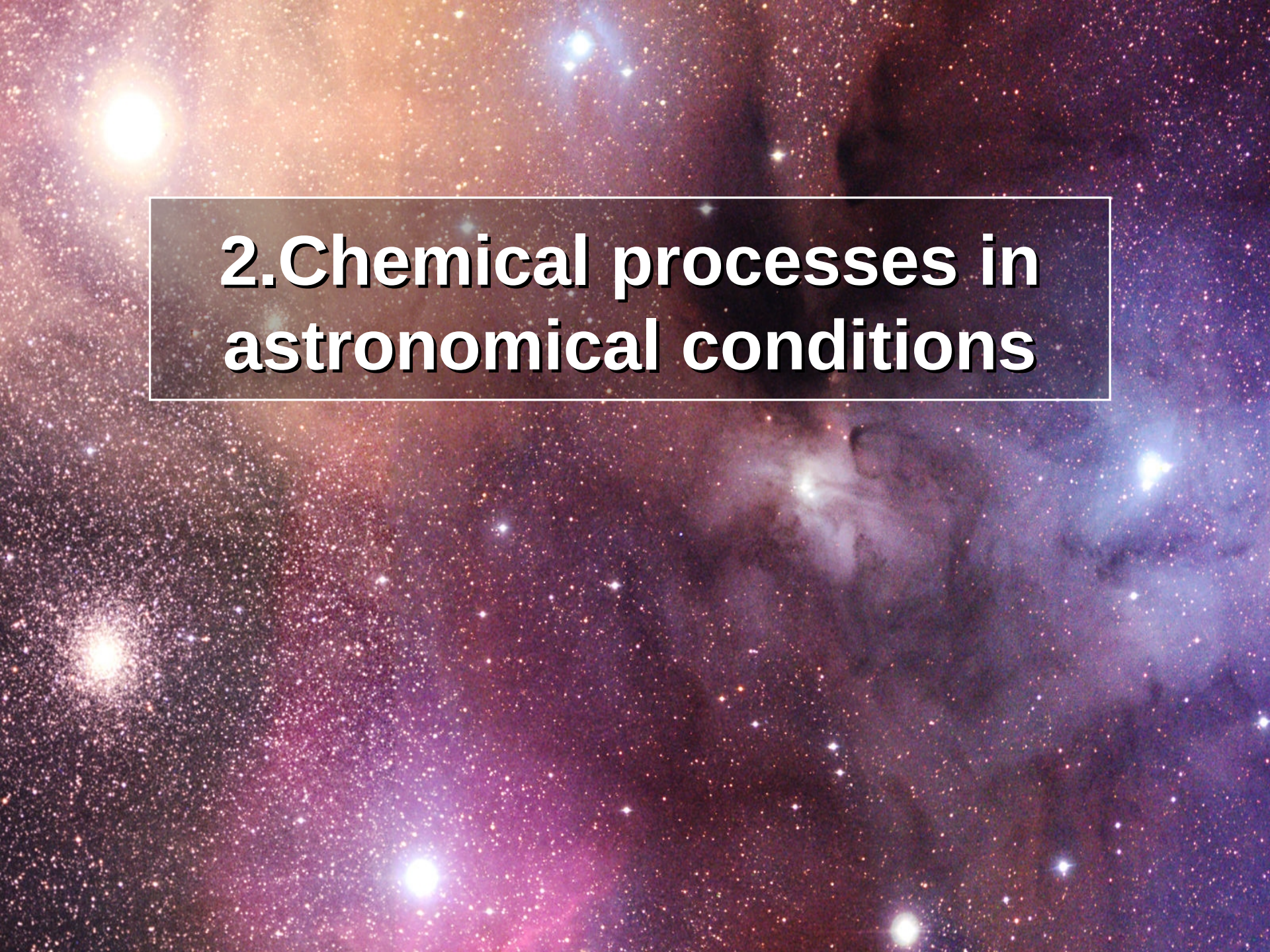
- unfamiliar physico-chemical conditions,
- the “laboratory” is inaccessible,
- exploration of scientific questions at the crossroad of several disciplines

- **Astrochemistry in a wider scientific context:**



**Molecular
spectroscopy**

- Progress in the exploration of molecular complexity
- Extension of the application fields of chemistry
- Significant input for astrophysics

The background is a rich, multi-colored star field. It features a dense distribution of stars in various colors, including bright yellow and white, deep red, and cool blue. The stars are set against a dark, almost black, space, which is filled with a fine, shimmering dust or gas. The overall effect is a sense of depth and vastness, typical of a star-forming region or a distant galaxy. A semi-transparent dark grey rectangular box with a thin white border is centered in the upper half of the image, containing the text.

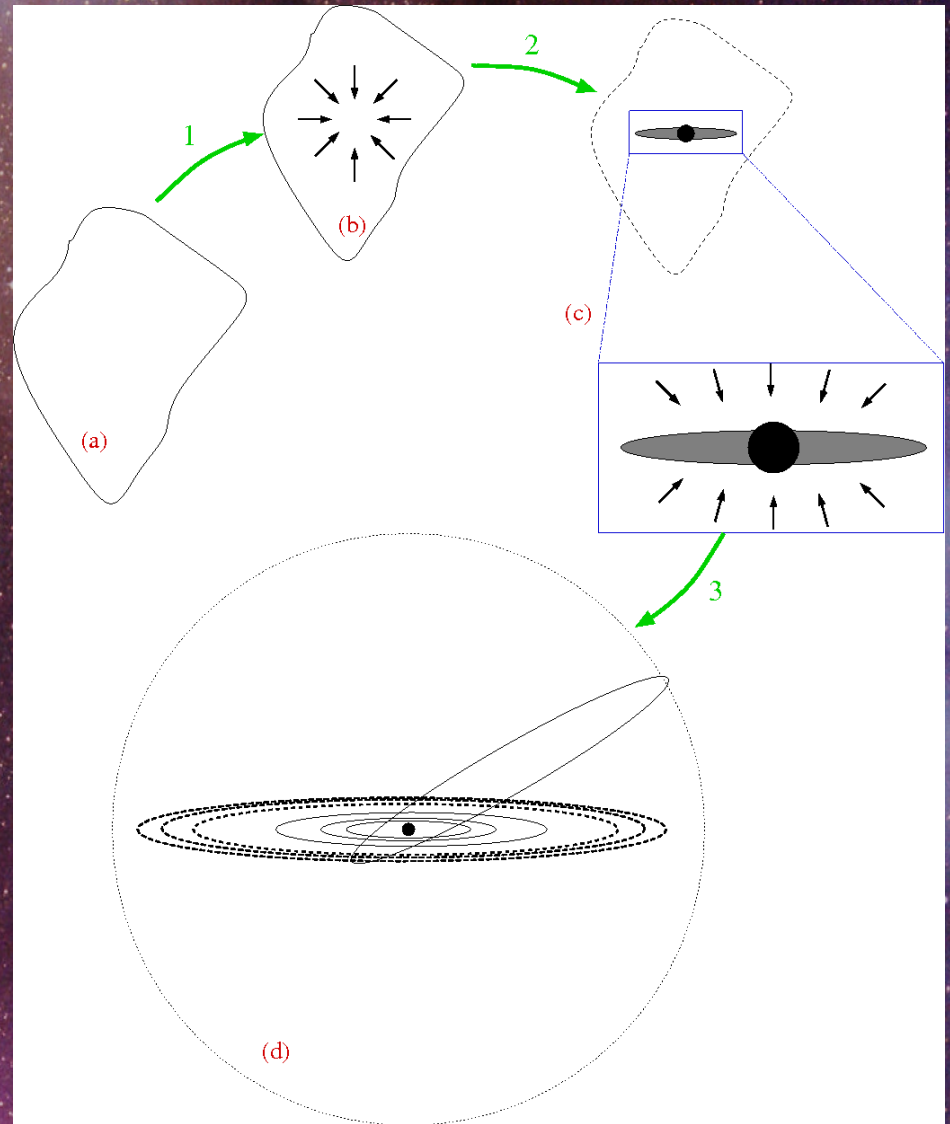
2. Chemical processes in astronomical conditions

(a) molecular cloud

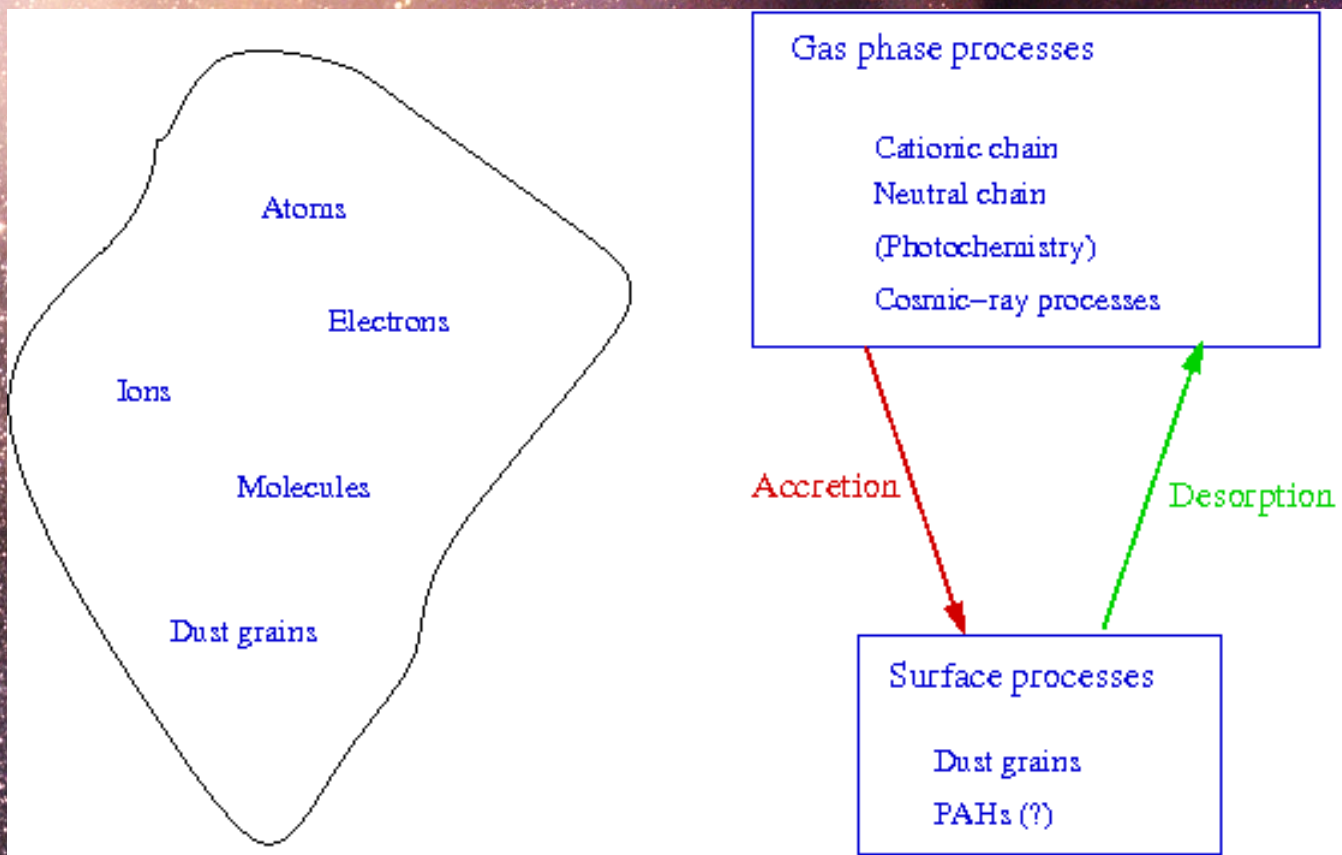
(b) proto-stellar object
(Class 0)

(c) proto-stellar object
(Class 1 or 2)

(d) planetary system



Molecular cloud chemistry



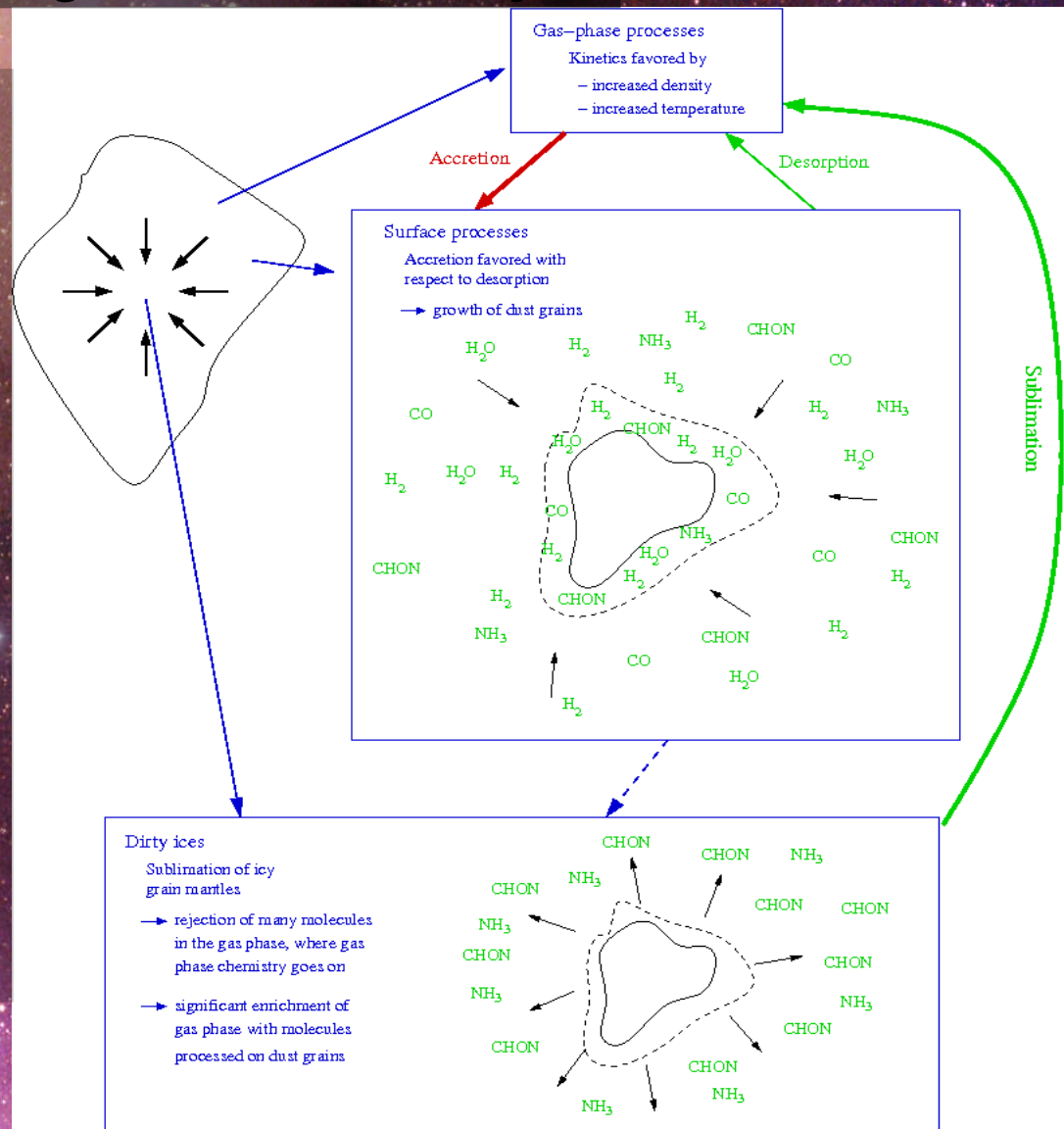
Collapsing cloud chemistry

Collapse of the molecular cloud

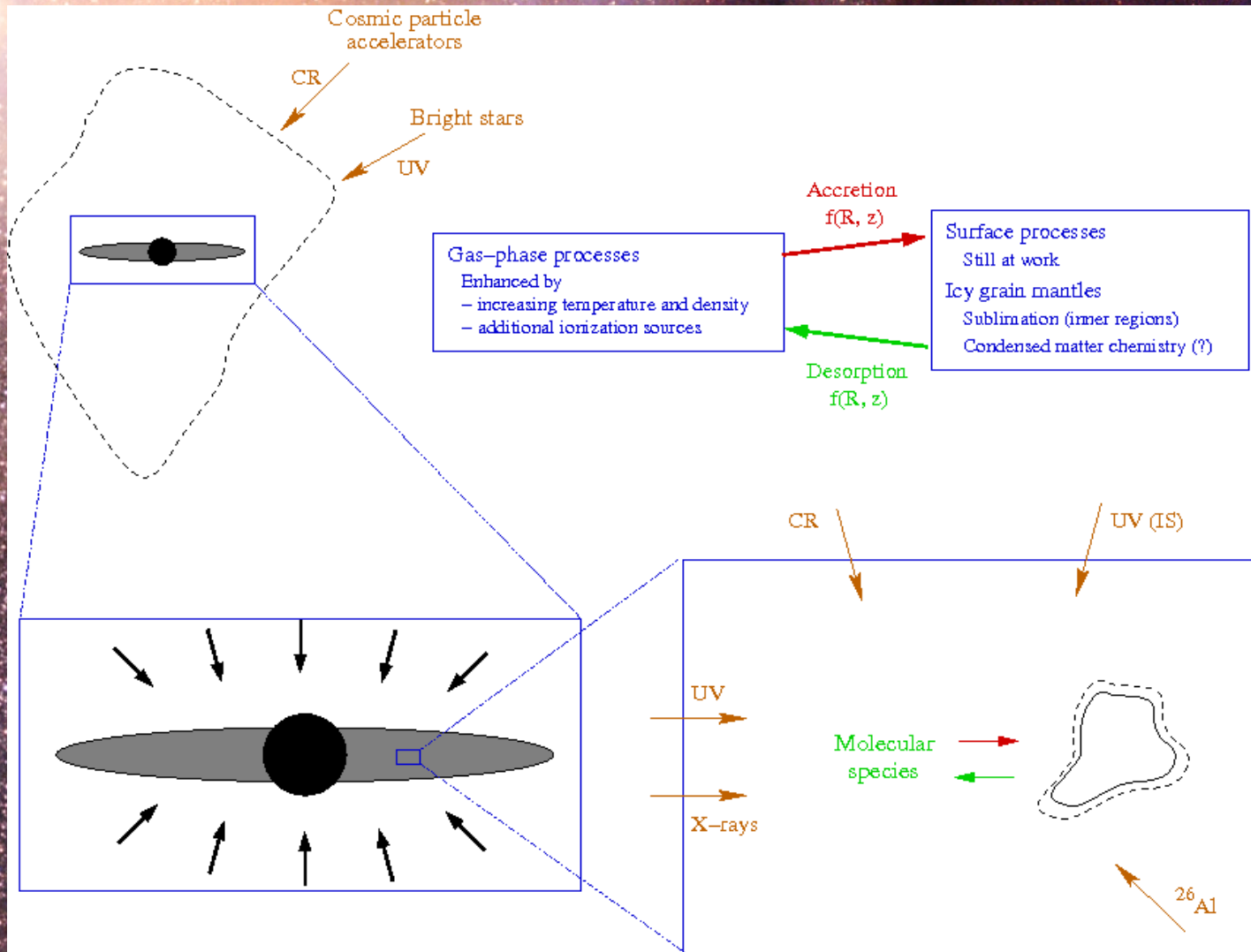
--> density increases and becomes significantly larger than in typical molecular clouds

Gradient of physical conditions

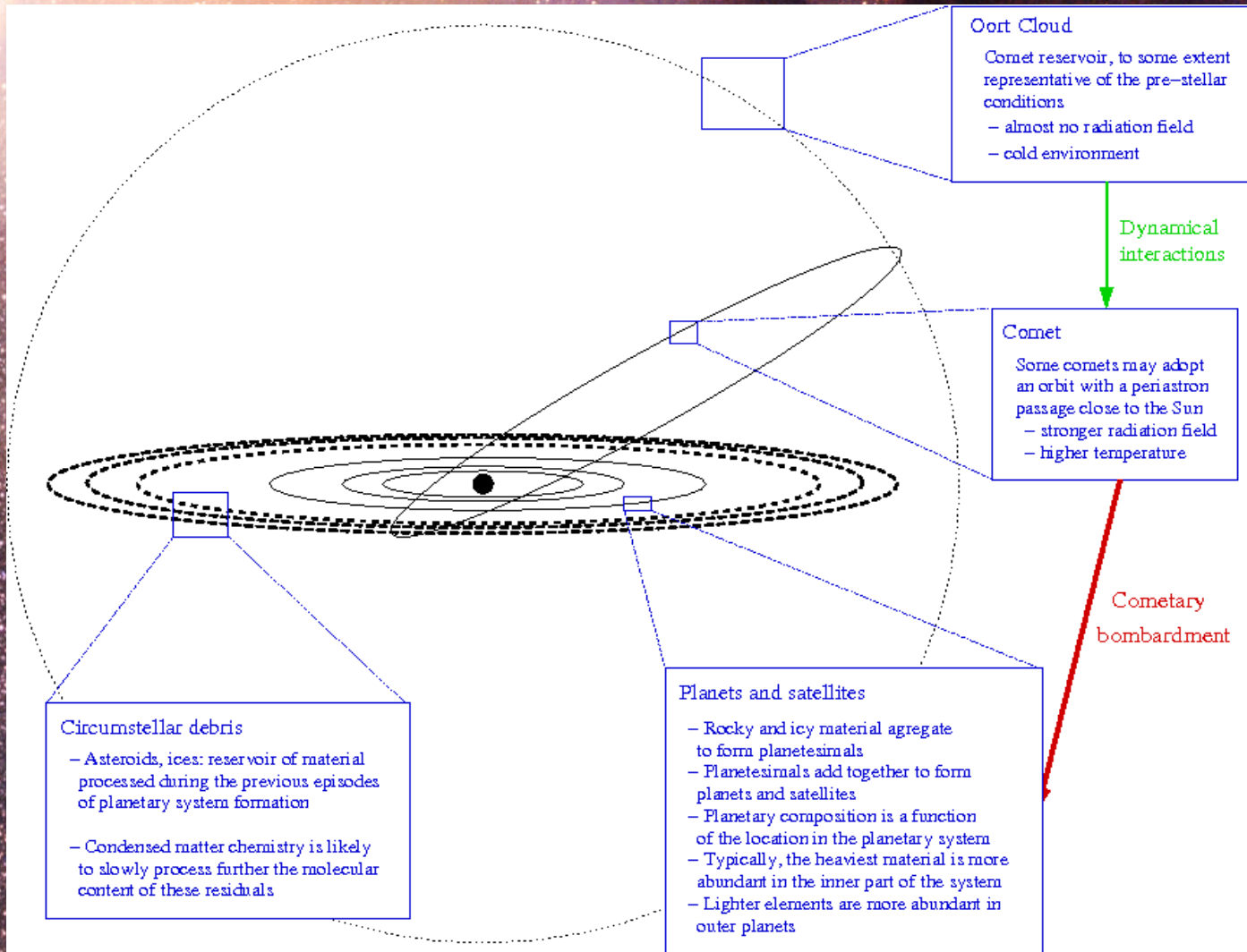
--> chemistry depends on the location in the collapsing cloud



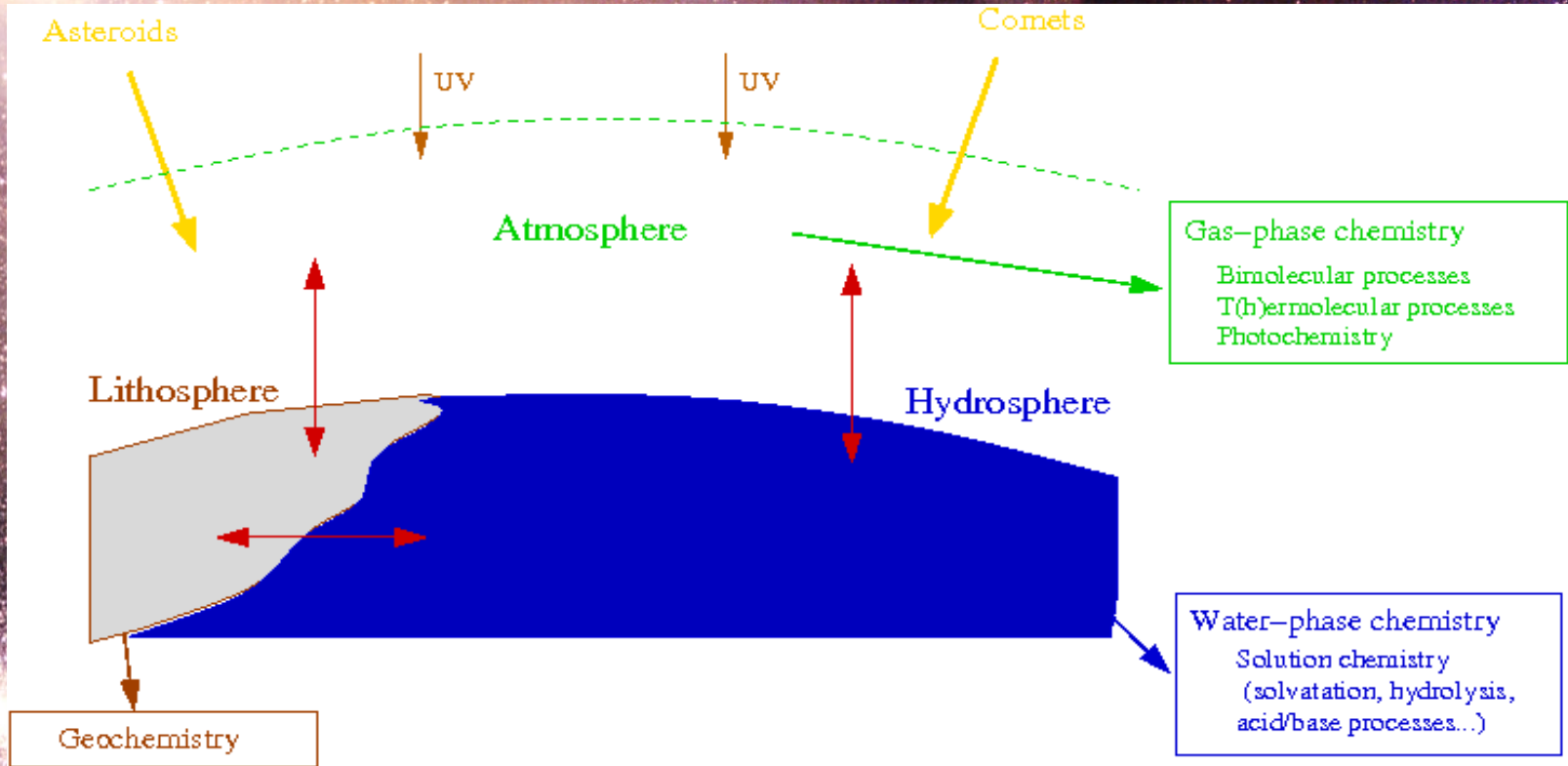
Proto-stellar object chemistry



(Inter-)Planetary system chemistry



Planetary chemistry



**Building blocks for the emergence of life
--> connection with Emmanuelle Javaux's talk**

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**3. What do we need to feed
astrochemical studies?**

3. What do we need to feed astrochemical studies?

- For specific conditions, chemical networks need to be established, in order to
 - **understand the mechanisms** responsible for molecular transformations
 - **make qualitative and quantitative predictions** on the molecular content of various environments

- Identify the adequate **physical conditions**
 - Select appropriate elementary processes
- Collect information on the **molecular content** of the selected environment (interstellar, proto-stellar, cometary, planetary...)
 - Input from spectroscopic studies, or solar system exploration missions
- Use the relevant **rate coefficients** for all elementary processes
 - Prior rate coefficient determination is necessary!!

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Potential new challenge for space exploration missions!!

There is no better space laboratory than Space itself!

- Could we imagine space mission designs to determine rate coefficients in space environments? For instance, photodissociation constants using the Solar UV radiation field
 - see for instance the LAMPS concept (M. De Becker, LiSRI) or the more ambitious VITRINE project (see Hervé Cottin's talk)
- Could we envisage to develop plasmon-based devices to monitor chemical reactions in space environments?
For instance, surface reactions on dust or ice analogs, and their interaction with Solar radiation...
 - surface plasmons technology in space mission concepts (see the talk of Karl Fleury & Serge Habraken)