Astrochemistry: a (very) brief introduction

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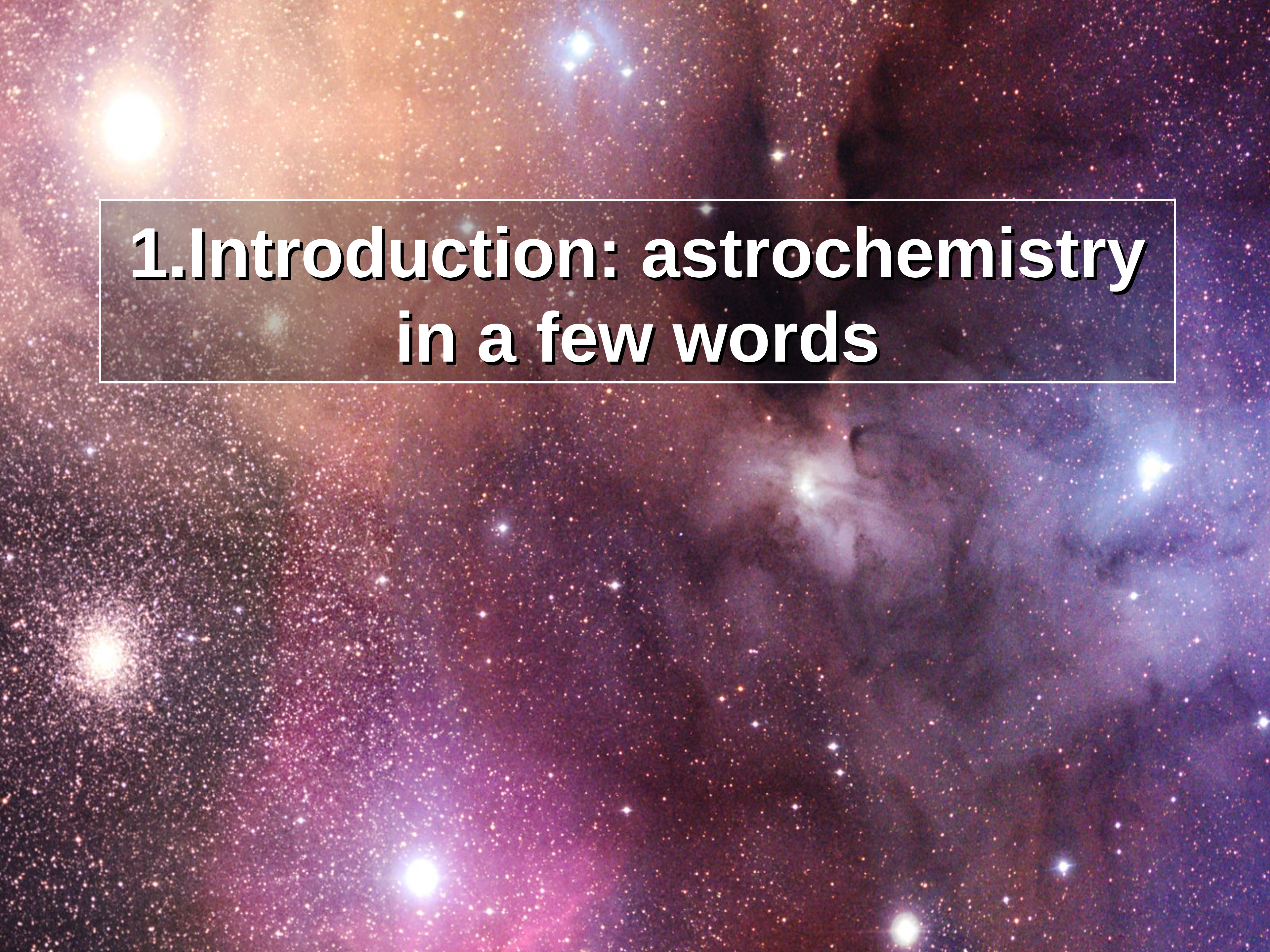
Astrochemistry: a (very) brief introduction

1. Introduction: astrochemistry in a few words

2. Chemical processes in astronomical conditions

3. What do we need to feed astrochemical studies?

1.Introduction: astrochemistry in a few words



1.Introduction: astrochemistry in a few words

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)

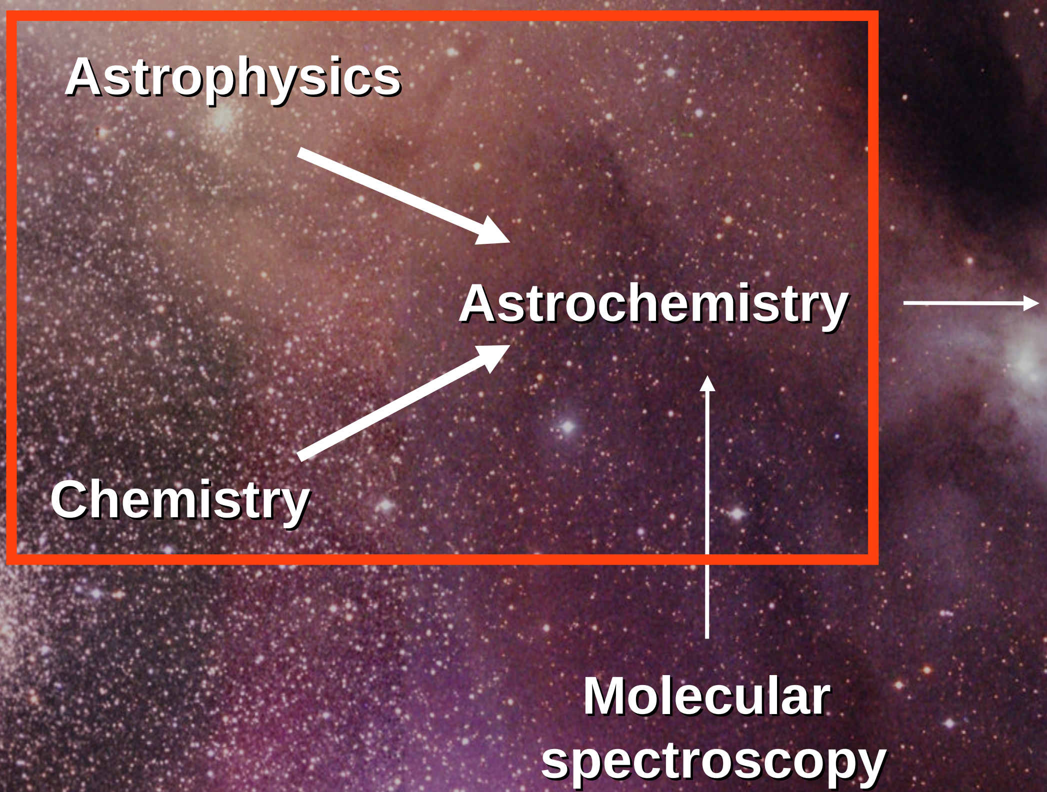
Chemical diversity and complexity:

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

The challenges of astrochemistry:

- unfamiliar <u>physico-chemical conditions</u>,
- the "laboratory" is <u>inaccessible,</u>
- exploration of scientific questions at the <u>crossroad of several disciplines</u>

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



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

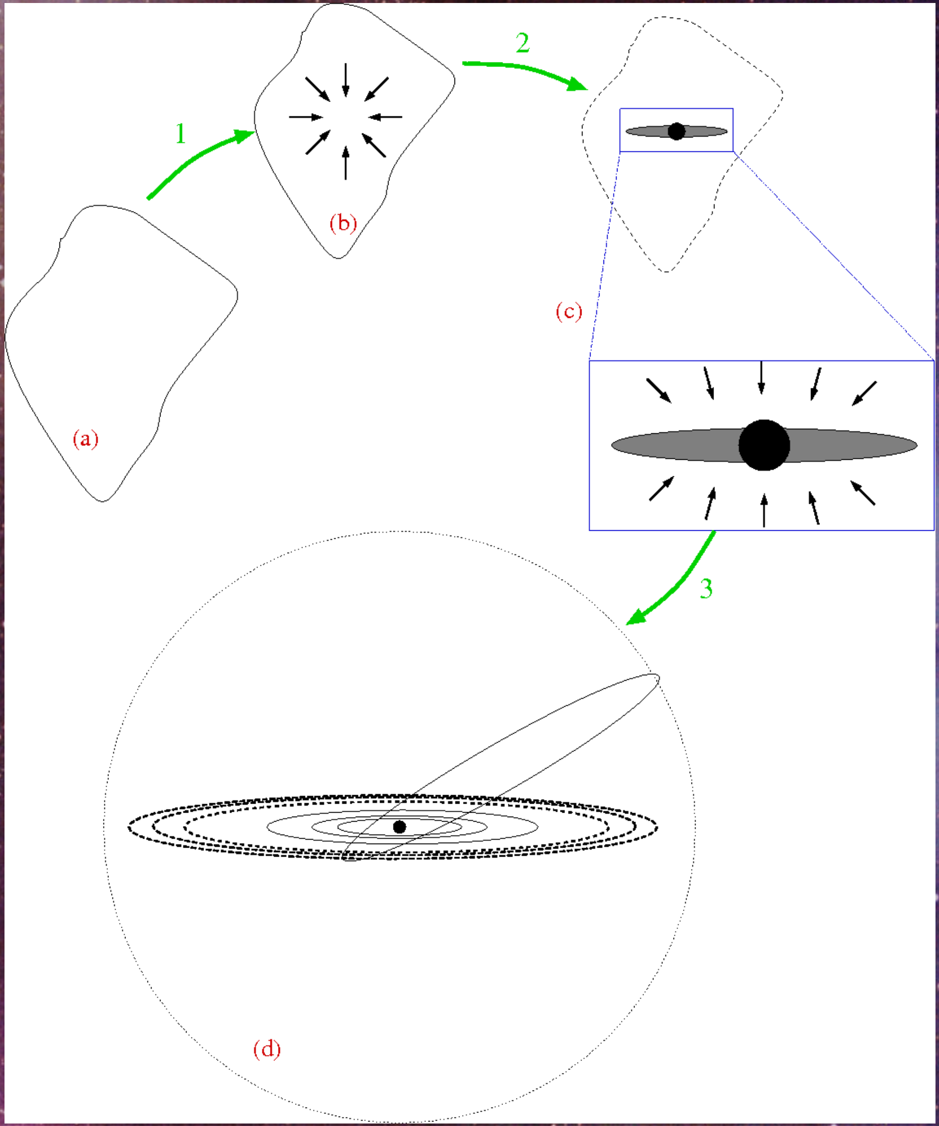
2.Chemical processes in astronomical conditions

(a) molecular cloud

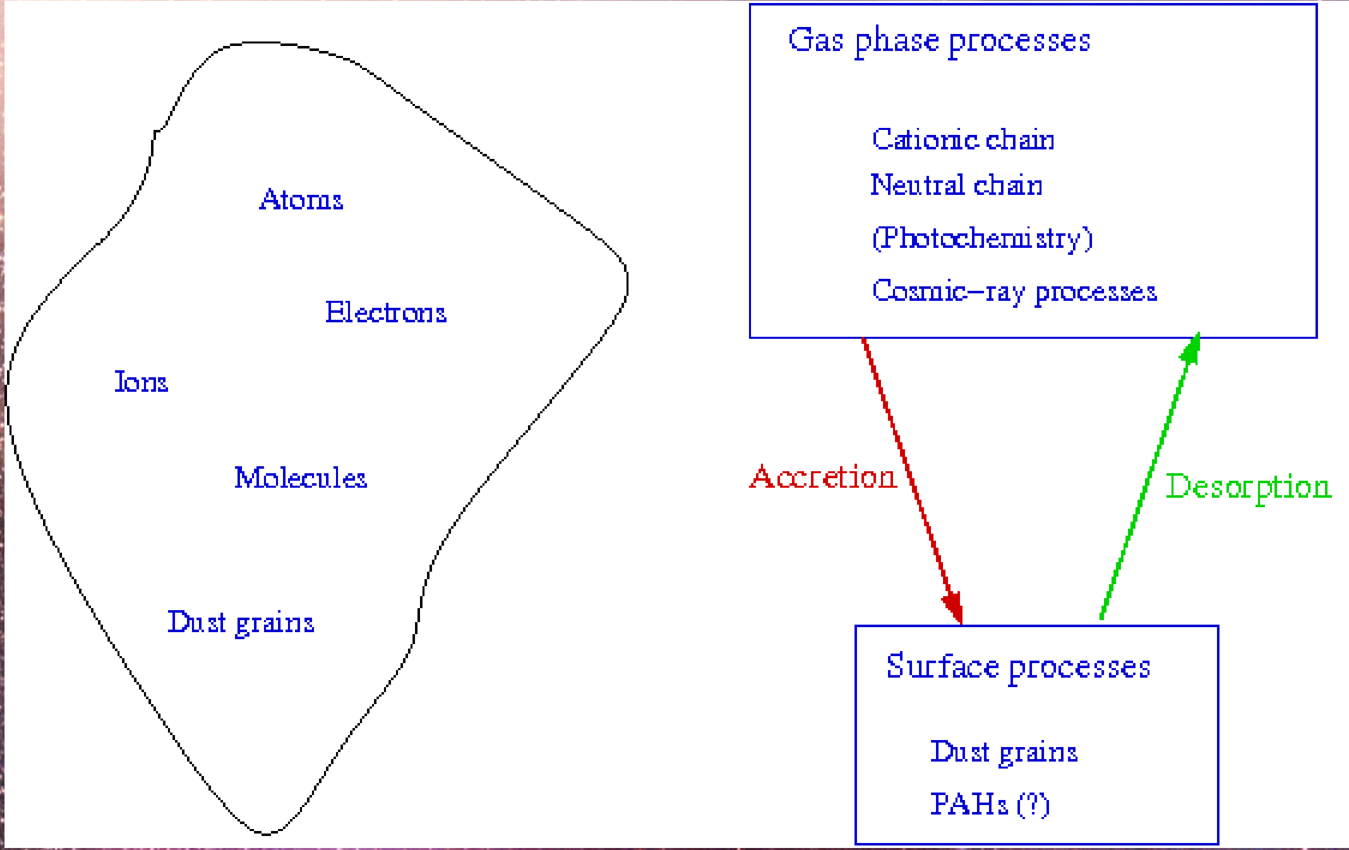
(b) proto-stellar object (Class 0)

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

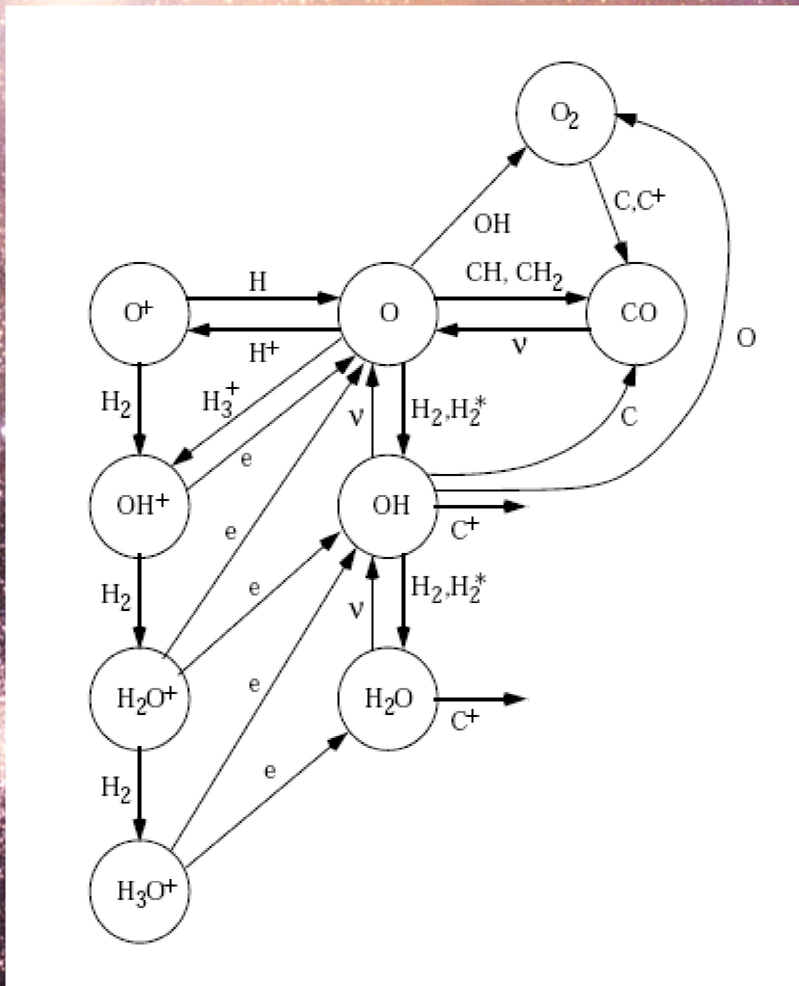
(d) planetary system

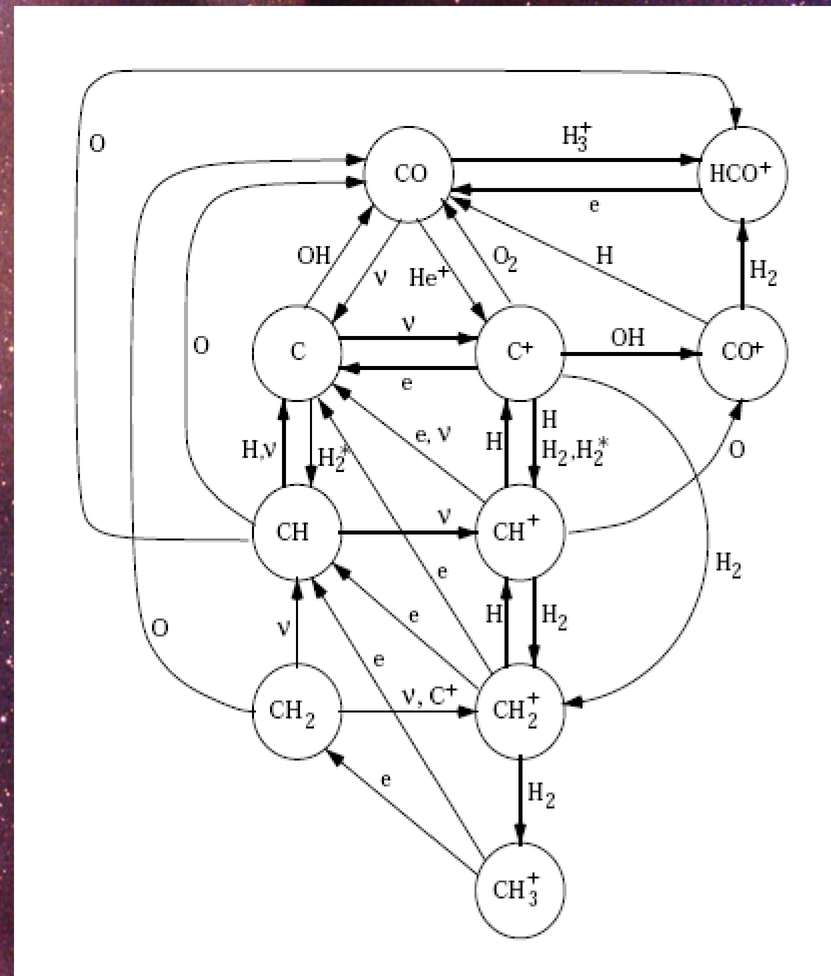


Molecular cloud chemistry



Molecular cloud chemistry : chemical networks





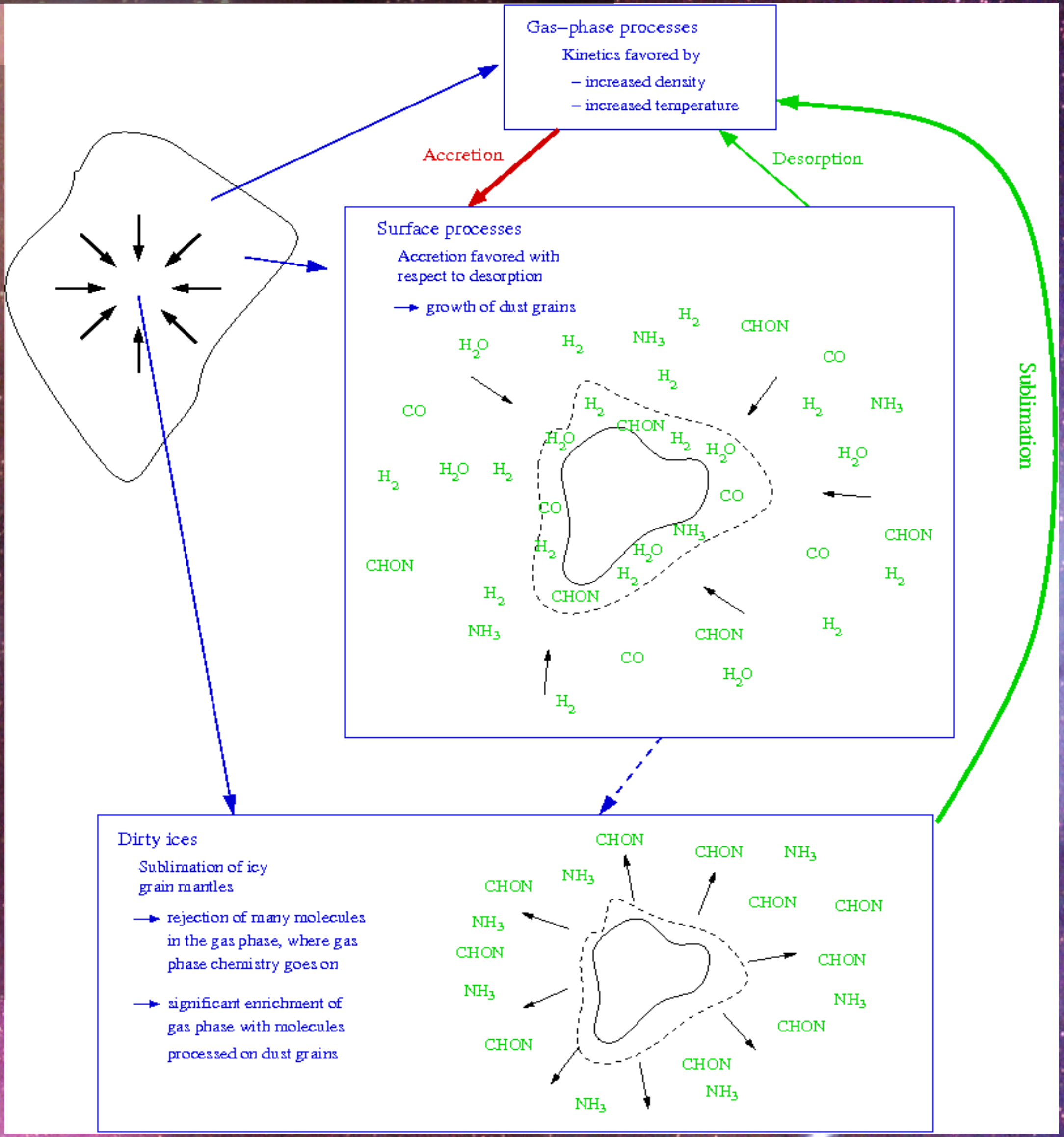
Collapsing cloud chemistry

Collapse of the molecular cloud

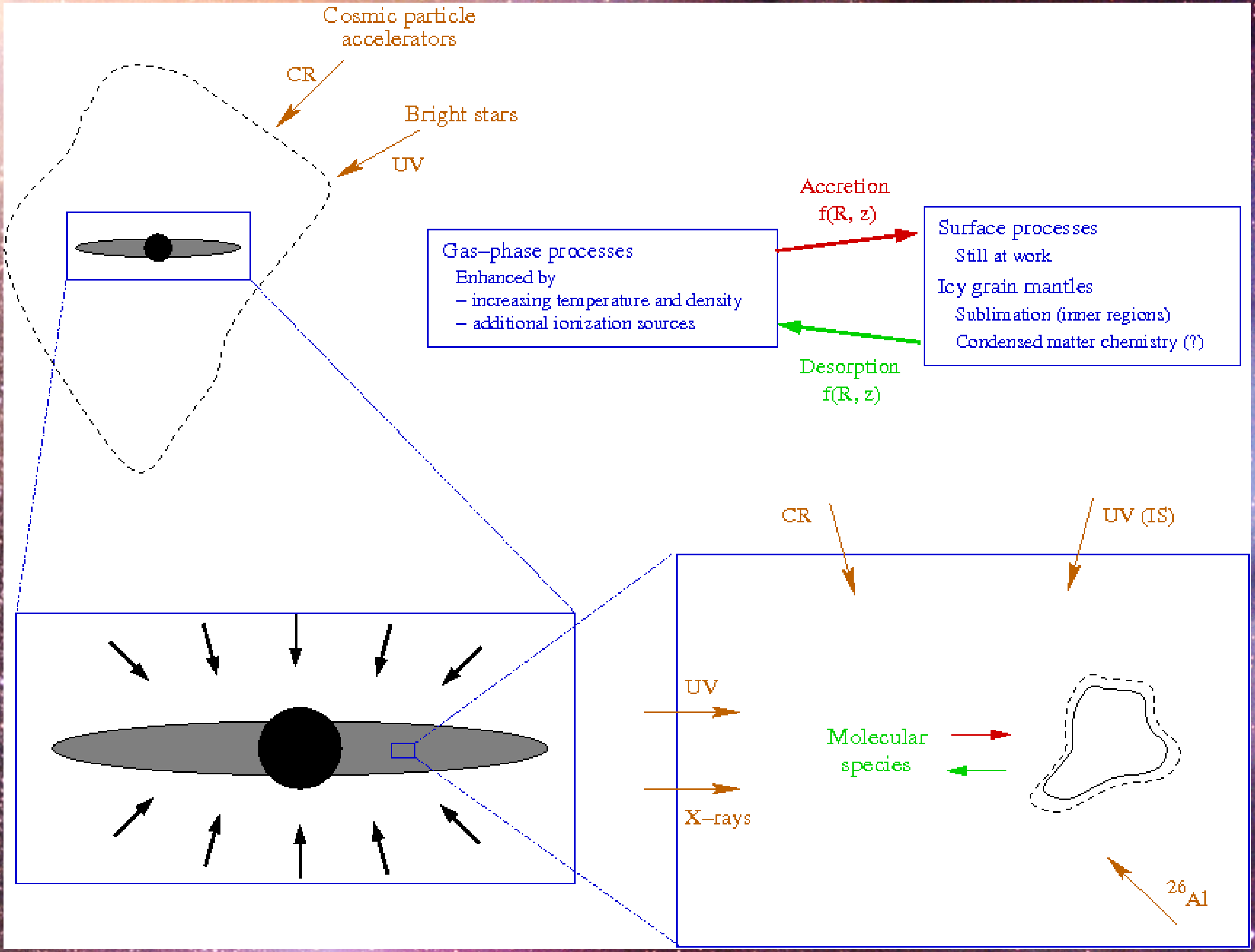
--> density increases and becomes significantly larger than in typical molecular clouds

Gradient of physical conditions

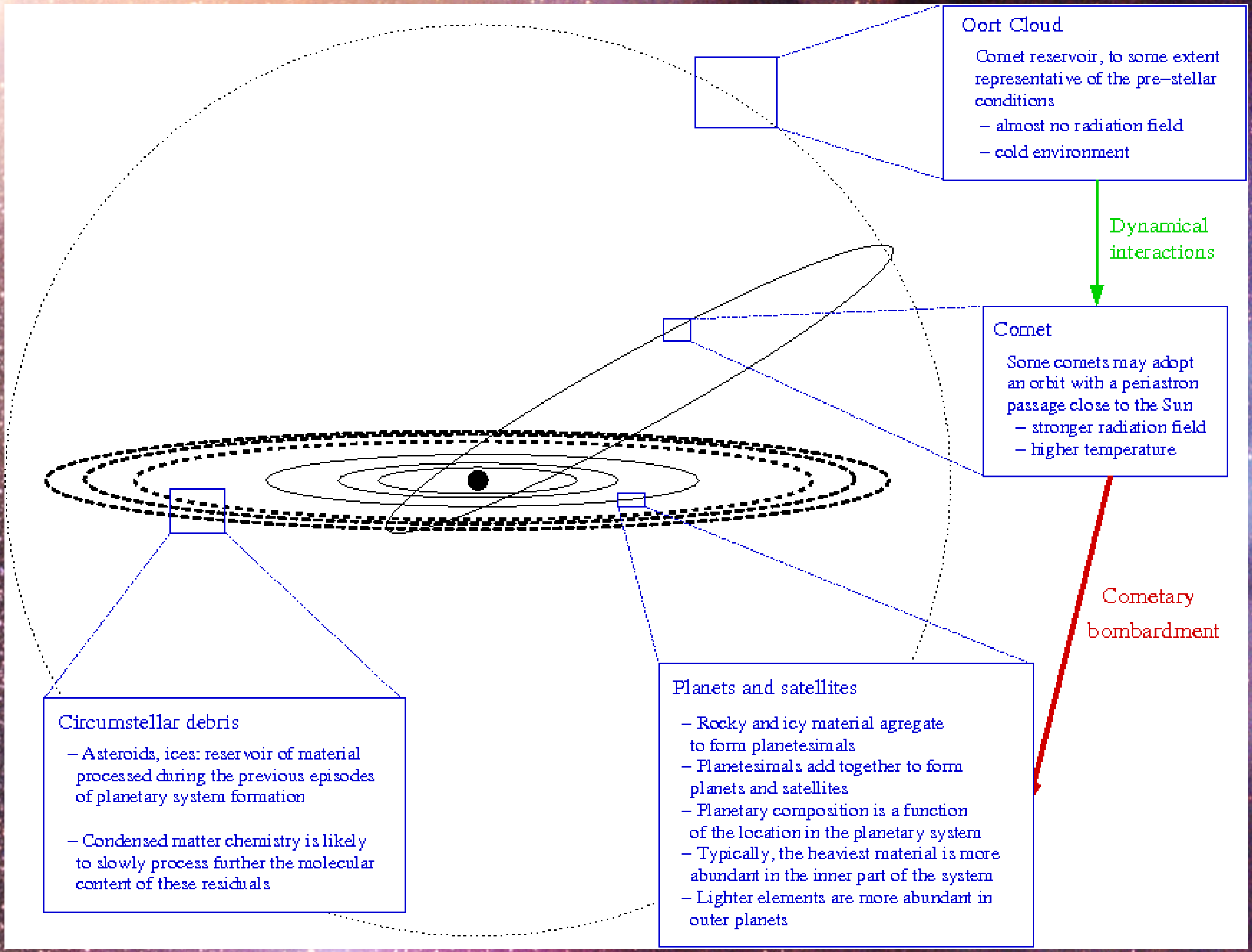
--> chemistry depends on the location in the collapsing cloud



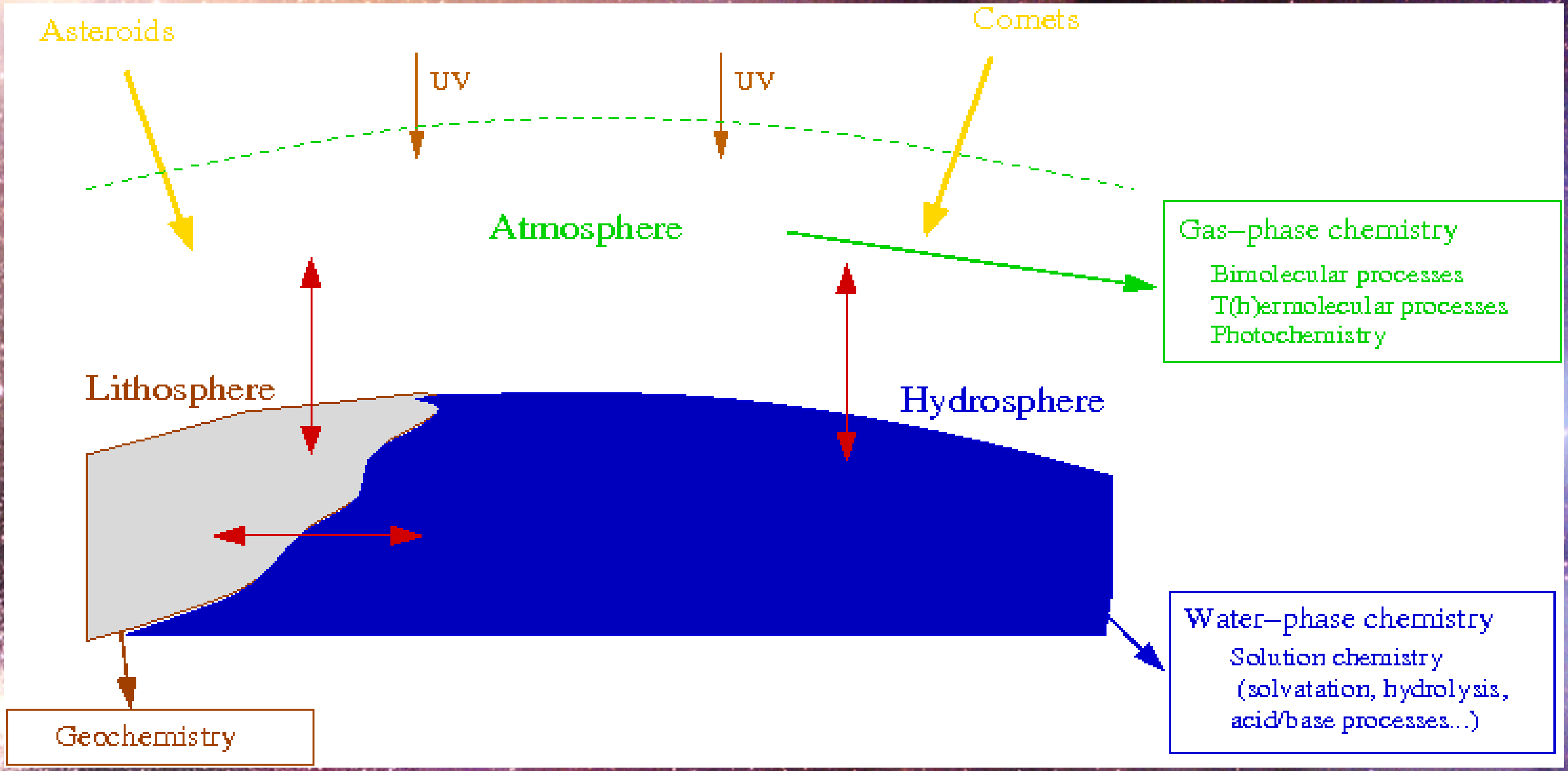
Proto-stellar object chemistry



(Inter-)Planetary system chemistry



Planetary chemistry



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

3.What do we need to feed astrochemical studies?

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- 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)