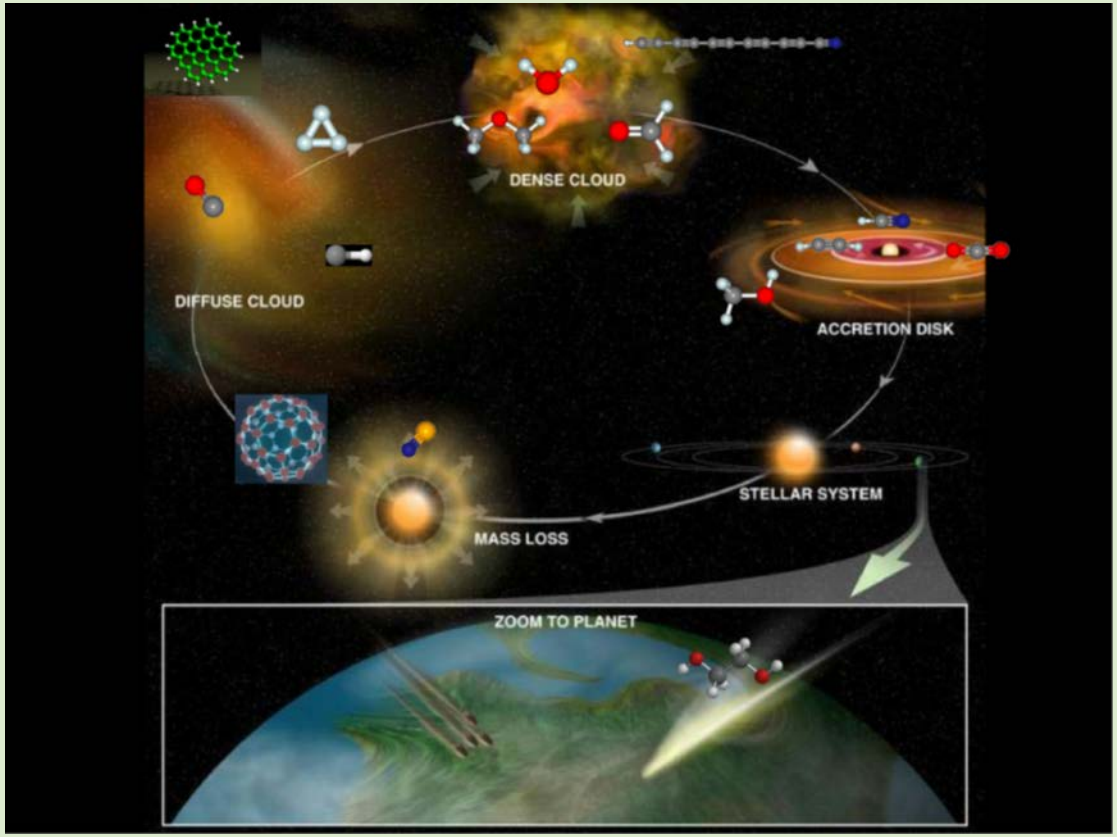
Astrochemistry

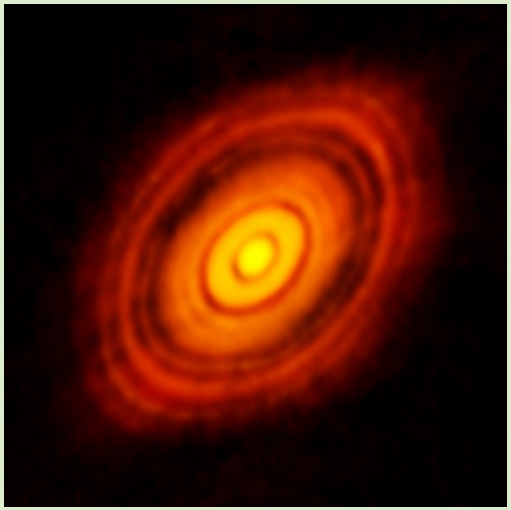


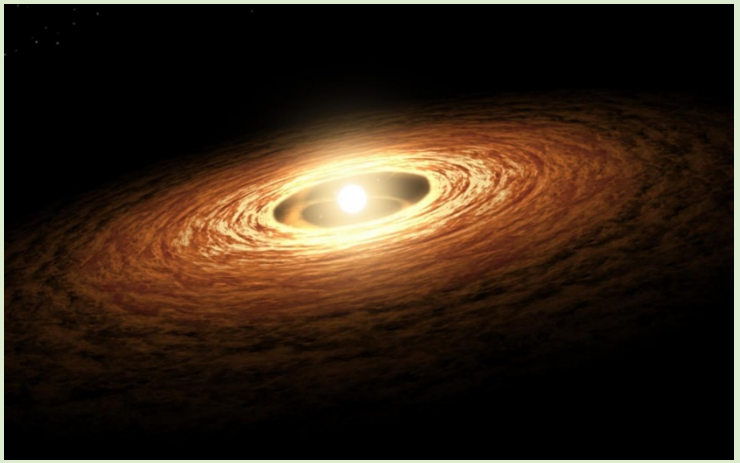
Lifecycle of gas and dust in interstellar space

'Astrochemistry is the study of the formation, destruction and excitation of molecules in astronomical environments and their influence on the structure, dynamics and evolution of astronomical objects' Alexander Dalgarno, 2008.

Astrochemistry

Astrochemistry started nearly a century ago and until today more than 200 different molecules have been detected in interstellar space, while ion H_3^+ is the most important ion.
Hydrogen (H_2) forms on the surface of dust particles and is ionized by cosmic rays to H_2^+, which then reacts quickly with H_2 to form H_3^+. From that point, water and hydrocarbons can be formed.

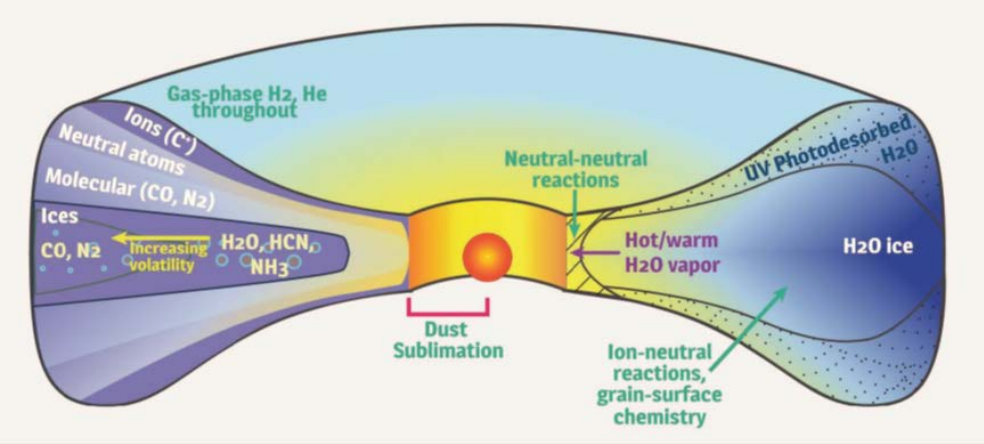




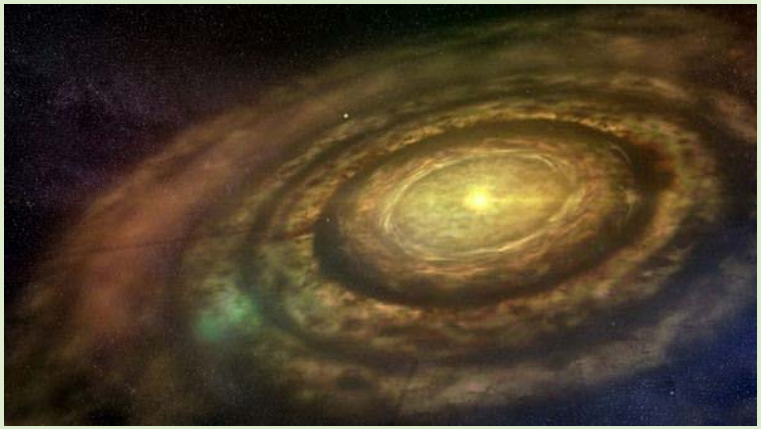
A protoplanetary disk, which is composed of two phases—a gas phase dominated by hydrogen and an ice phase dominated by water.

Astrochemistry

A protoplanetary disk is a disk of gas (99% by mass) and dust (1%), orbiting a newly formed star, from which planets are (hypothesized to be) formed.

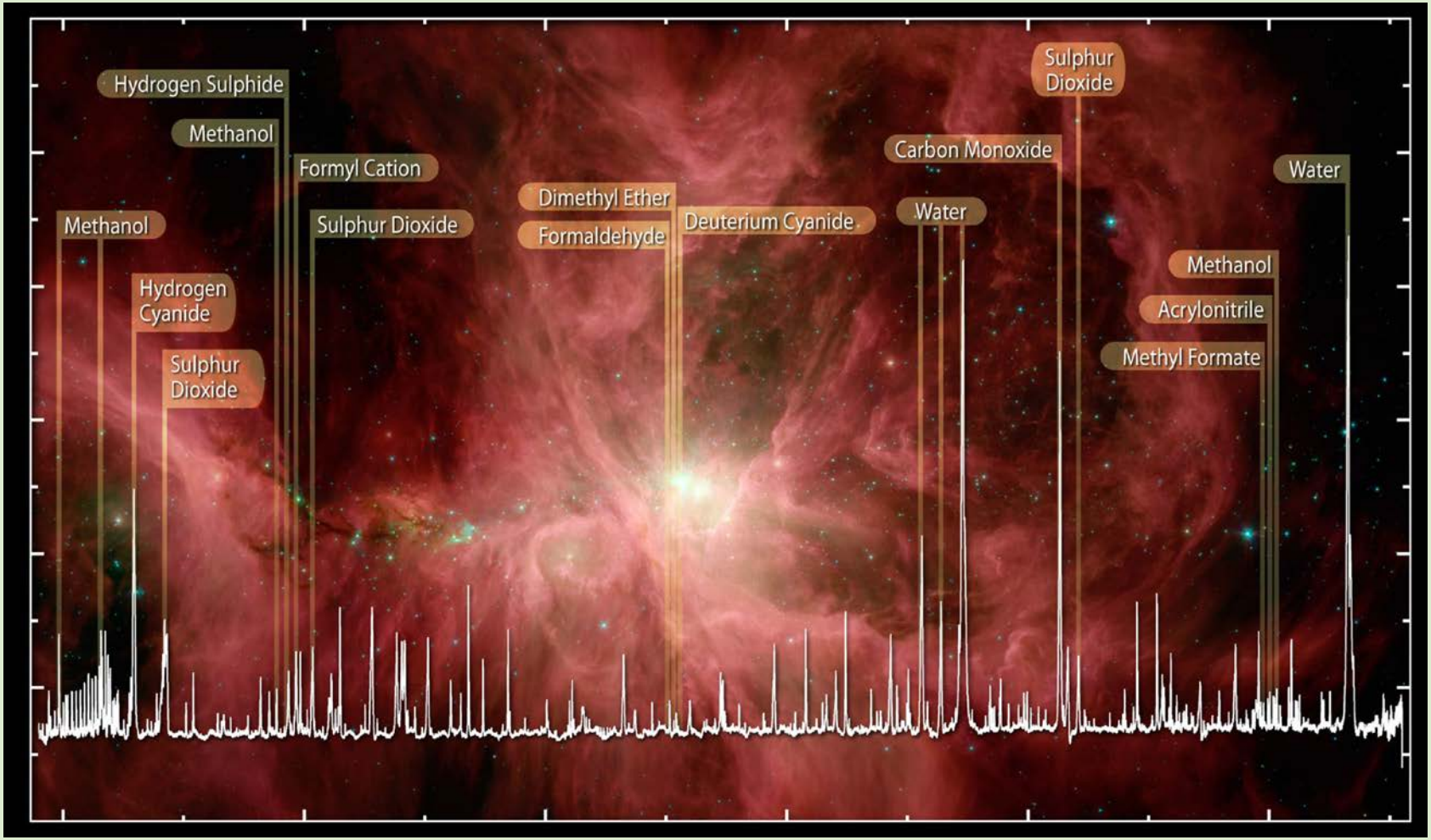


Protoplanetary disk composition. Source: Cleeves (2018)(NRAO/AUI/NSF).



This artist's conception shows a newly formed star surrounded by a swirling protoplanetary disk of dust and gas. Credit: University of Copenhagen/Lars Buchhave

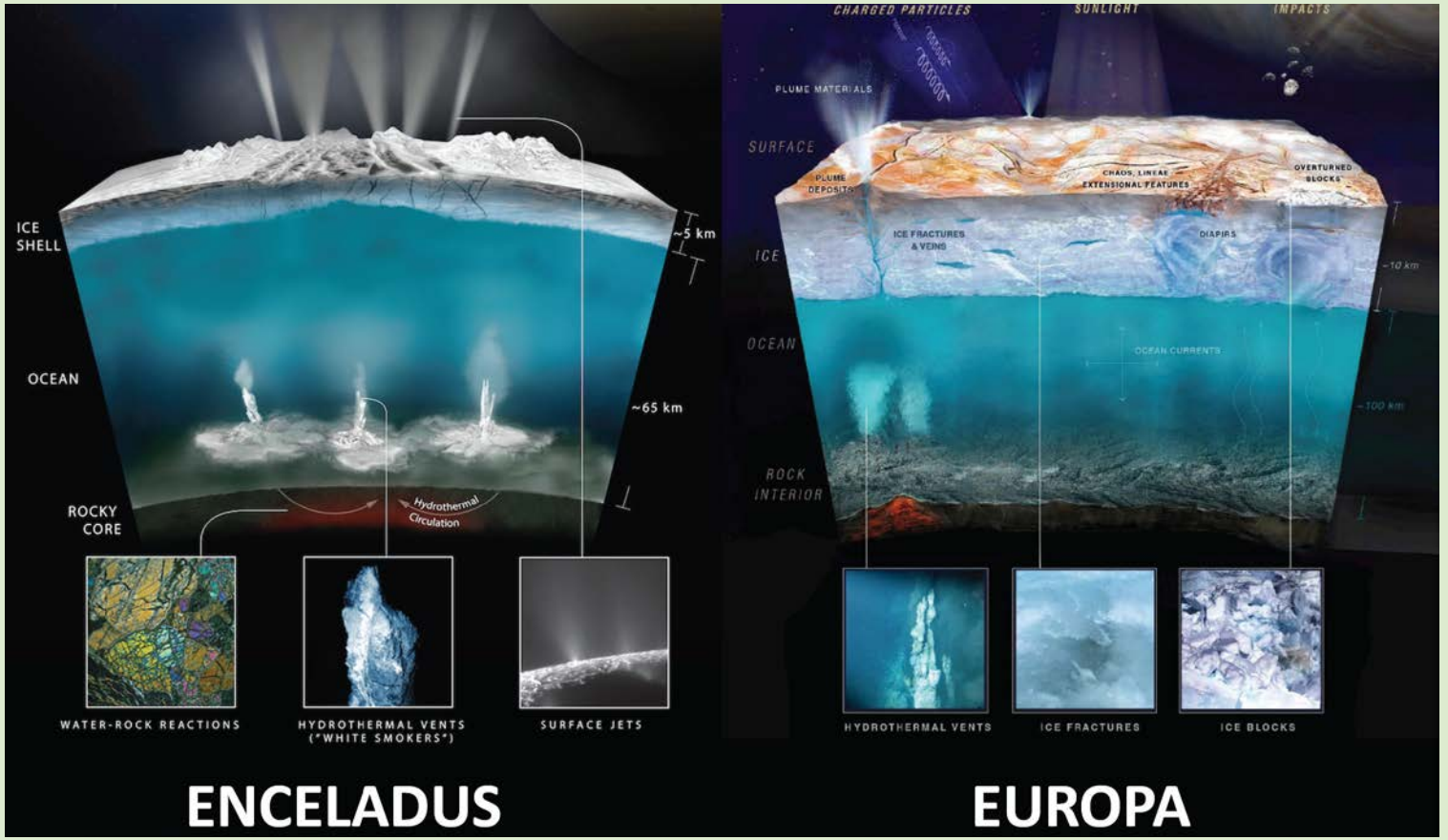
Astrochemistry



Herschel-HIFI spectrum of the Orion KL region, showing strong emission from water and organic molecules, superposed on a Spitzer image (NASA/JPL-Caltech/S.T. Megeath) (Bergin et al. 2010).

Astrochemistry

Europa and Enceladus have an ice crust beneath which is a liquid-water ocean that sits on a rocky core.



The oceans beneath the icy mantles of Enceladus and Europa.
Source: NASA/JPL-Caltech/Southwest Research Institute.

Astrochemistry

Evolved stars. Large surveys of emission from the carbon monoxide (CO) molecule and other molecules show that evolved stars are losing mass in the form of stellar winds at relatively low outflow speeds.

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