Focus: Entry Descent and Flight in Planetary Atmospheres

Outer Planets: Science and Mission Concepts
Jonathan Lunine (Invited) and the TiPEx Team
Not Afraid to Ride the Wind: Titan by Balloon
Sushil Atreya (Invited) Saturn Probes: why, where, how?
Thomas Spilker (Invited) Mission Design Aspects of Planetary
Entry Probe Missions
Tibor Balint & Participants of the SSEP Study, JPL,
On the Feasibility of a New Frontiers Class Saturn Probe Mission
David Atkinson Direct to Earth Communication

plus a dozen posters

Comparative planetology of the outer planets is key to the origin and evolution of the Solar System, and, by extension, Extrasolar Systems

Formation and Origin: what must be known?

abundances of heavy elements* in well-mixed atmosphere, i.e.

Bulk Composition

*m > 4He
formation of Jupiter and origin of atmosphere

*gravitational instability: protoplanetary clumps
*core accretion model
- core from grains of ice, rock, metal
- core grows to critical mass (~10 M⊕)
- gravitational collapse: most volatile gases (H₂, He) captured
- atmosphere from H₂, He; and gases released from core
- planetesimals added throughout the formation (and afterward) to explain heavy element enrichment
  - cold icy planetesimals
  - clathrate hydrates, "cold", nevertheless

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Cylindrical Maps of Jupiter: 1° S – 14° N
NASA Infrared Telescope Facility
Middle Infrared Array Camera: 4.6μm

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ratio of planetary to solar elemental abundances
Cassini at Saturn

- atmos <1 bar; magnetosph. → exceptional!
- C/H = 9 x solar (from CH₄) measured by CIRS
- P/H = 5 - 10 x solar → disequilibrium, ISO/CIRS
- O, N, S, noble gases and their isotopes? no
- isotopes (D/H, ^3^He/^4^He, ^14^N/^15^N)? no
- deep winds, dynamics? no

formation, and atmospheric origin: what must be known?

heavy element* abundances in well-mixed atmosphere, i.e. bulk composition

* m/z > ^4^He

![Diagram showing ratio of planetary to solar elemental abundances](image)

![Diagram showing temperature and pressure](image)
Saturn Probes

how deep → shallow or deep?
• probes only: deep (50 - 100 bar), or
• probes + microwave radiometry: shallow (~10 bar)

how many?
• 2 - 3, for diversity and risk mitigation

where?
• equatorial, mid- and/or high latitudes

Juno Microwave Radiometry

Radiometry sounds the deep atmosphere

Determines and maps the water and ammonia global abundances

Saturn Probes

critical measurements:
• composition of well-mixed atmosphere
  C, O, N, S, noble gases and their isotopes
  D/H, 3He/4He, 14N/15N isotopes
  GeH4, SiH4, AsH3, PH3, CO: internal process
• deep winds, dynamics
• core determination?
Saturn Probes

technology challenges
- tps (heat shield):
  - left over from Galileo probe; enough for two probes?
- communication:
  - direct-to-earth, or relay?
- power:
  - solar arrays (battery assisted?), or rps/rf/g?
- probe technology (light probes?)
- microwave radiometry (on flyby s/c or probes, e.g.)?
  atmospheric modelling: MWR retrievals; communication...

→ Study underway at JPL

Saturn Probes

flyby spacecraft, with
two shallow probes plus microwave radiometry

NASA’s New Frontiers program