# HIGH SPECTRAL RESOLUTION SYSTEMS FOR SOLAR SYSTEM EXPLORATION AT FREQUENCIES UP TO 600 GHZ

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Near future mission opportunities

- Venus: explore middle atmosphere chemistry and dynamics as reference for Earth current and future

- Mars: seek atmospheric signatures indicative of extant subsurface geological and/or biological activity

- Europa/Jupiter Flagship: seek evidence in sputtered atmosphere for Europan subsurface ocean and/or biology

- Titan/Saturn Flagship: characterize prebiotic chemical composition and dynamics in Titan atmosphere (also Enceladus)
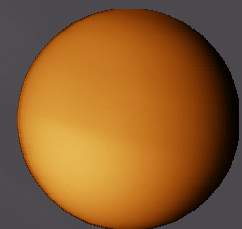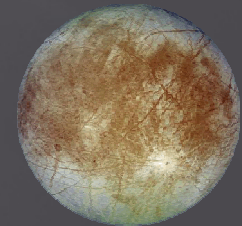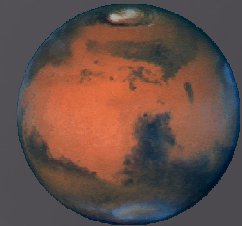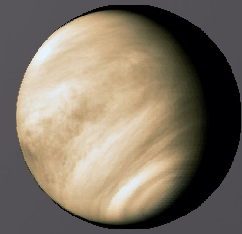
Typical measurements

- Atmospheric composition
- Atmospheric state
  - Temperature
  - Gas flow (direct measurement of winds)
- Surface temperature

Measurement requirements

- Detect isolated spectral lines with high S/N
- Resolve spectral line shape for good pressure registration
- Have highly accurate frequency calibration to optimize line of sight wind measurement using Doppler shift
- Include as many distinct lines as possible in a single spectrum
- Switch band center frequencies as rapidly as possible to maximize "simultaneous" measurements

Instrument options

- Passive detection
- Radar spectrometer

- Remote sounding
- In situ, absorption cell

Instrument requirements

- Really low mass
- Really low power
- Maximum sensitivity
- Very high spectral resolution
- Very broad instantaneous spectrum
- Rapid frequency switching

- Passive cooling
- Radiation hardening (particularly for Europa)

Both mm and sub-mm measurements required

- Example: Europan orbiter spectrometer

Molecule	Nadir absorption		Limb emission		Limb sun absorption	
	100 GHz	600 GHz	100 GHz	600 GHz	100 GHz	600 GHz
CO	Not practical	Not practical	42%	8%	13%	0.3%
HCN	22%	3%	0.1%	0.01%	0.03%	0.0004%
NH_3	Not practical	15%	33%	0.07%	10%	0.002%
H_2S	Not possible	Not practical	Not possible	6%	Not possible	0.2%
CH_3OH	Not practical	Not practical	26%	8%	8%	0.2%
CH_3CN	36%	Not practical	0.2%	5%	0.05%	0.15%
NaO	12%	40%	0.06%	0.2%	0.02%	0.01%
MgS	3%	Not practical	0.01%	0.8%	0.004%	0.02%
NaCl	2%	Not practical	0.01%	2%	0.003%	0.05%

Detectable mixing ratio relative to background H_2O

- Detection of heavier molecules improved at lower frequencies