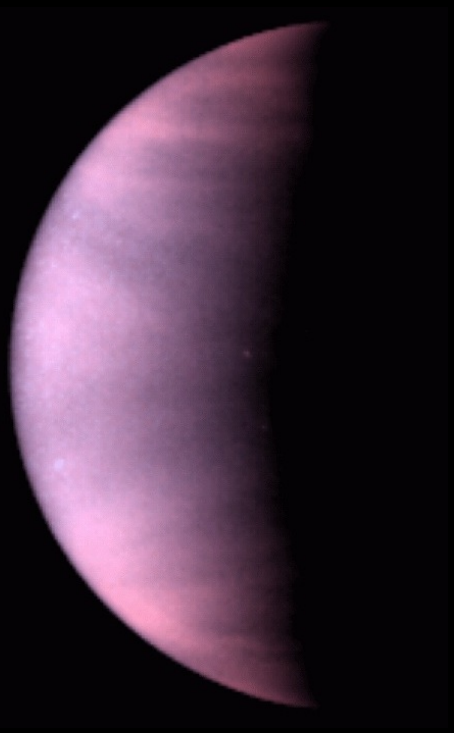
Coordinated Sounding Rocket, HST, and SPICAV Observations of Venus in Nov. 2013

Fall AGU
P14A-08



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Science Background - Isotopic Ratios

Assume Venus, the Earth, and Mars all started with the same amount of water and the same HDO / H_2O ratio

Water near the surface will rise until the temp/pressure lead to condensation (clouds) - above that level the air is dry, and little water is photo-dissociated by solar UV light:

$$H_2O + h\upsilon\ (UV) \rightarrow OH + H \qquad \text{and same for HDO}$$

H and D diffuse as H_2 to the top of the atmosphere, and can "boil off" into space if their thermal speed exceeds the escape speed

H escapes faster than D due to mass difference, and D/H ratio increases as more water escapes

Today: Earth D/H ~ 1.6×10^{-4} Mars ~ 9.3×10^{-4} Venus ~ 0.05

Did Venus lose an ocean of water into space?

Measurements of deuterated water from Pioneer Venus and IR spectra both gave D/H ~ 0.05

Present escape depends on D/H atoms at the top of the atmosphere, look at UV H (and D) Ly α (reflected sunlight)

IUE UV spectra of Venus in early 1980's resolved D and H Ly α lines (0.33 Ångstrom separation from mass difference) but did not detect D line, upper limit 1/6 of that expected (Bertaux and Clarke 1989)

Complications:

Rates of condensation are different for HDO and H_2O (well known from Earth atmosphere) - will act to remove more D than H in middle atmosphere, more H_2O subject to solar UV

Rates of photo-dissociation of HDO and H_2O are different - will also differentiate species mixed into upper atmosphere

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A campaign has been organized for Oct/Dec 2013 to address:

- the loss of water into space

- the diffusion of hydrogen upward through the atmosphere

- the relative loss rates of D and H

One goal is to detect the D Lyman α line and derive the atomic D/H ratio (sounding rocket "VeSpR" and HST)

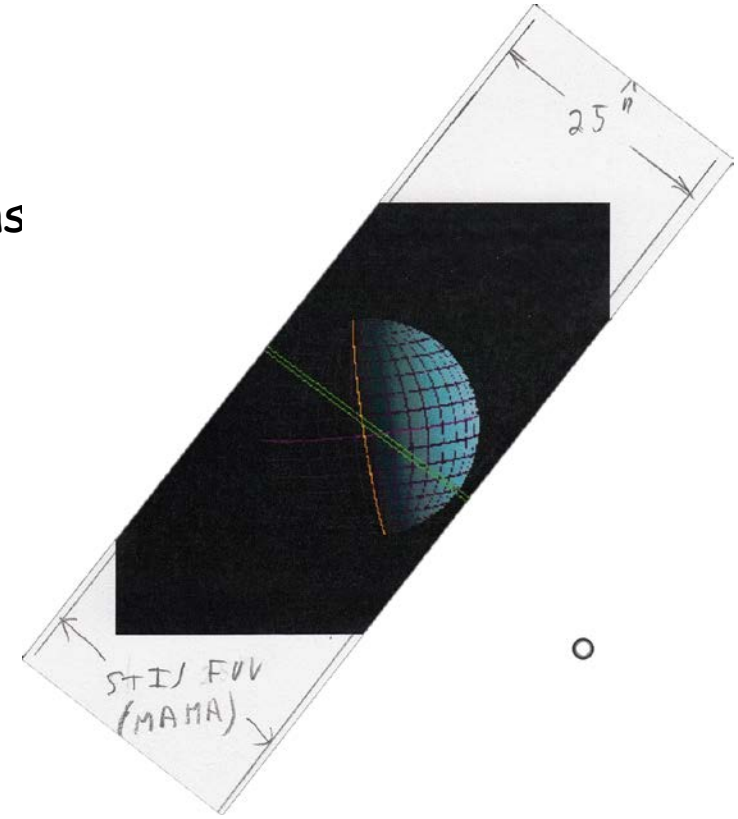
Another goal to measure the altitude profile of HDO and H_2O in the middle atmosphere (SPICAV on Venus Express).

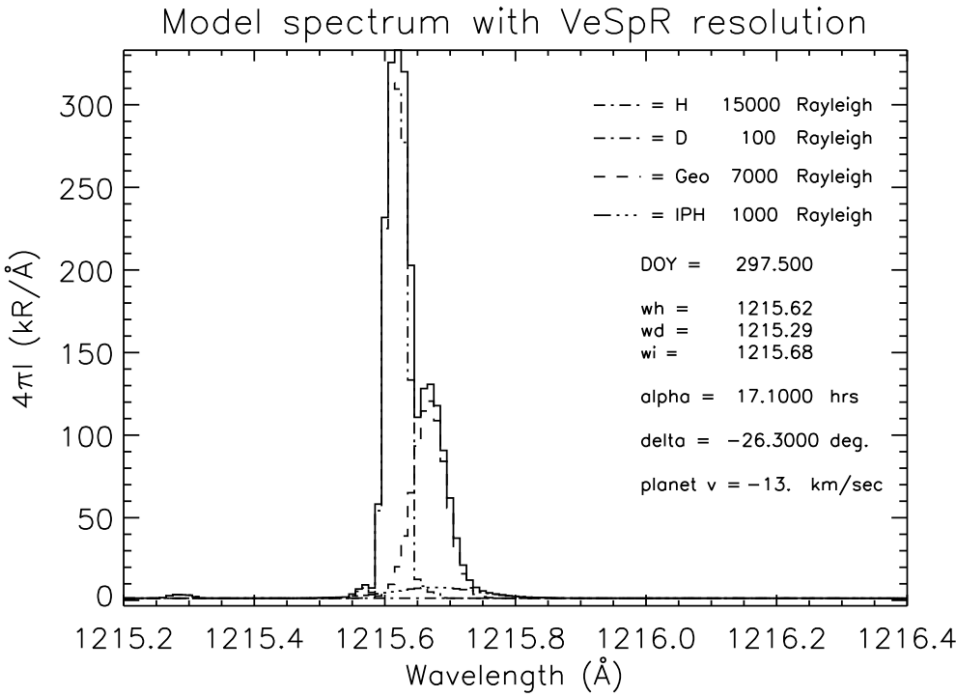
HST Venus Observations on 24 Oct.

look at Venus while HST in earth shadow
lines doppler shifted from LOS orbital motions

Observing geometry w/ long aperture ->

Aperture angle fixed, FOV limited
to disc of Venus





<- Simulated STIS echelle spectrum with geocoronal, Venus, and IPH emissions spectrally resolved

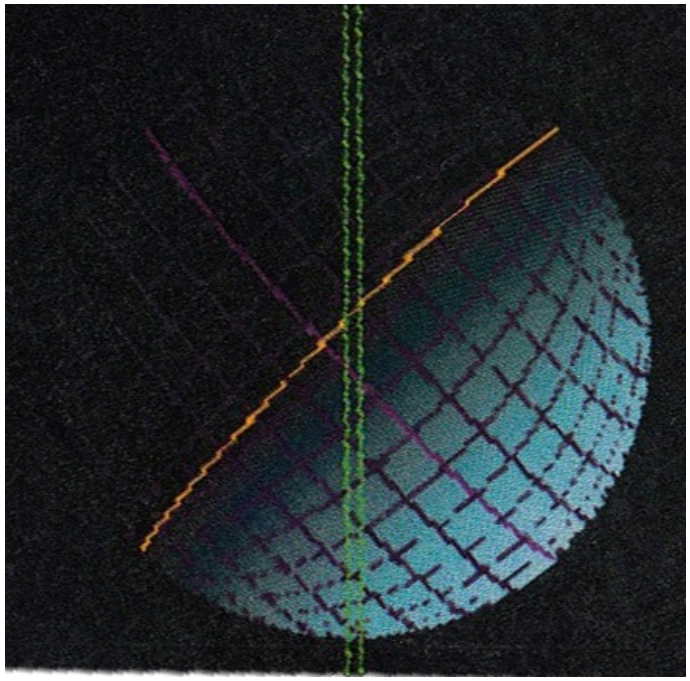
HST Observations of Venus on 24 Oct. 2013:

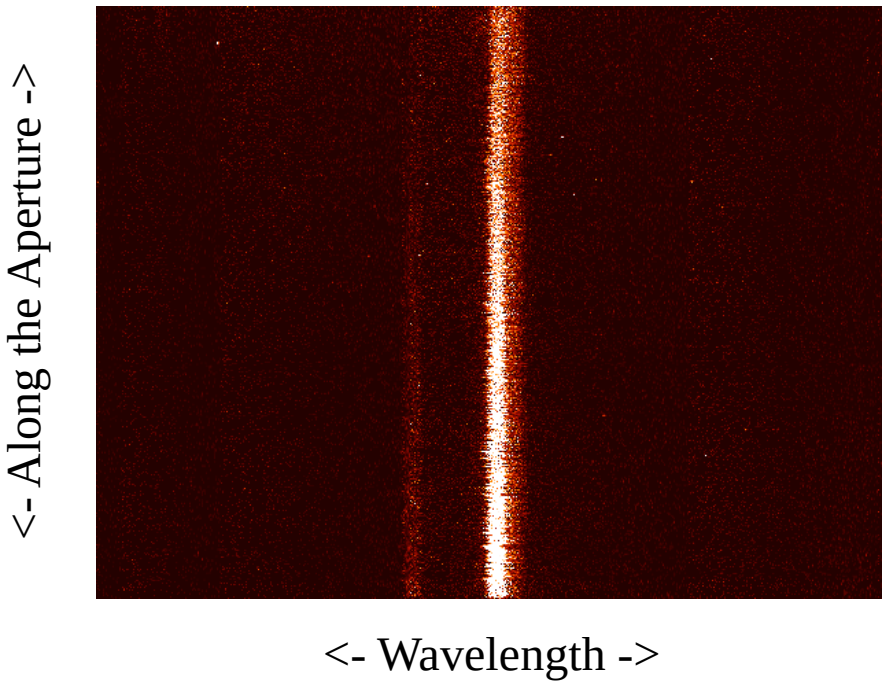
Quick look at HST data ->

Venus and geocoronal H Ly a emissions just resolved

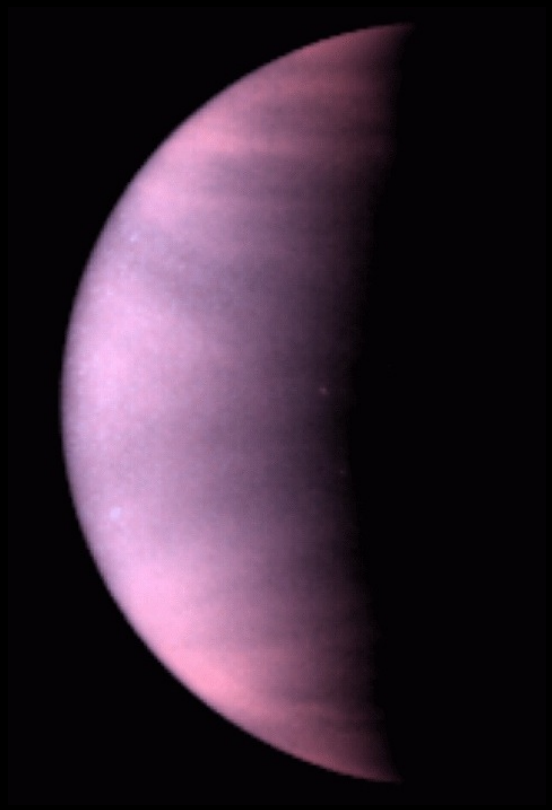
D Ly a emission clearly detected with intensity profile across disc

Aperture Orientation on Venus:





The Venus Spectral Rocket Experiment (VeSpR)



Launched at WSMR on
26 Nov. 2013

Investigators:

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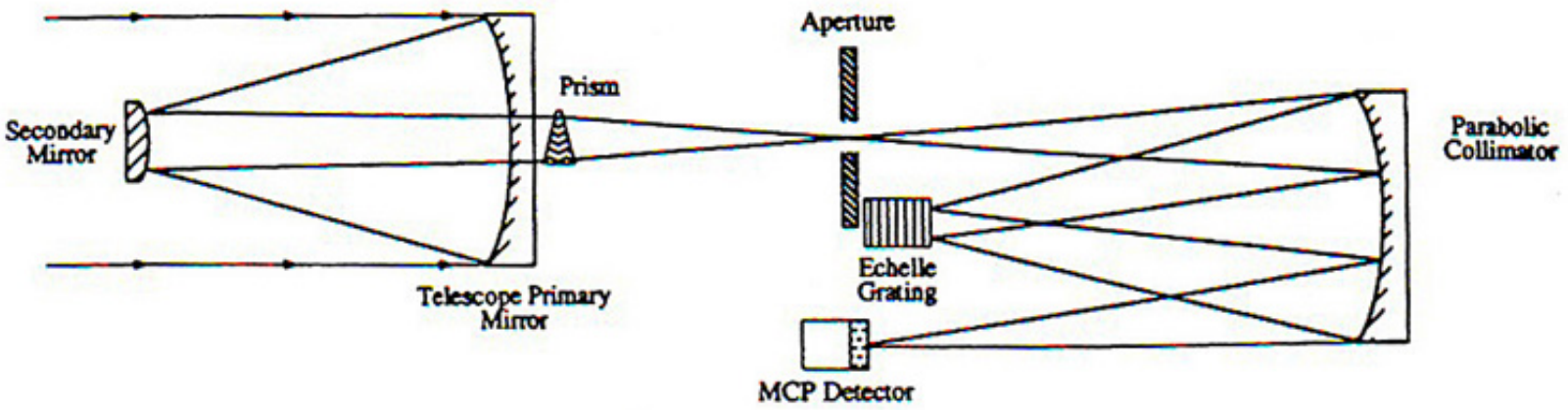
Jean-Loup Bertaux	LATMOS / BU
Jeff Hoffman	MIT

VeSpR:

Layout of the telescope and echelle spectrograph:



Launched on 26 Nov. 2013 from White Sands Missile Range, Venus was acquired as expected and both MCP detectors worked, quick look data indicate lower than expected count rate but a few thousand counts in the spectral channel

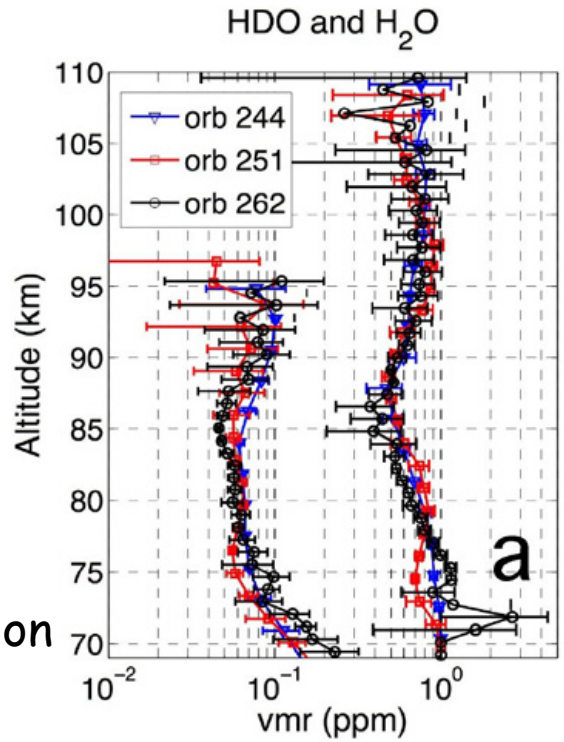
We will need to analyze the data in detail to learn more.

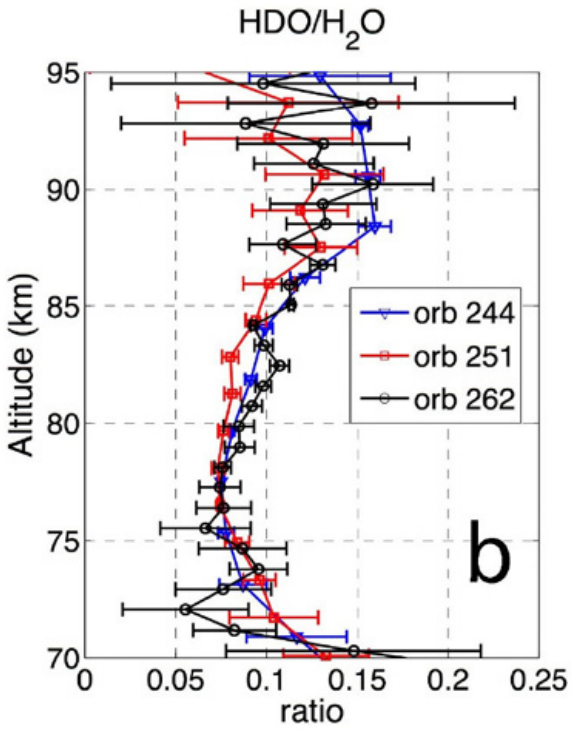
SPICAV: Venus' middle atmosphere has been measured by the SOIR experiment on Venus Express. IR occultations provide altitude profiles of densities of H_2O and HDO (Bertaux *et al.* 2007):

The decrease in HDO/H_2O between 70-85 km is unexpected and unexplained:

HDO/H_2O ratio is also higher than 0.05 for bulk atmosphere

May reflect differences in condensation and dissociation rates of H_2O and HDO….





SPICAV observations set to begin 11 Dec. 2013 in post-eclipse season

Summary of Venus Campaign:

HST and VeSpR measure the D and H Ly α line emissions from the upper atmosphere, derive D/H ratio above the water

HST has high angular resolution and can measure the profile across the disk, incl. limb brightening peak – gives altitude information about distribution of emission

HST executed on 24 Oct., and VeSpR launched on 26 Nov.

HST data are high quality and clearly show the D emission, but do not extend off the planet disc for background measurement

VeSpR has long aperture for better measurement of sky background

SPICAV observations are constrained by s/c geometry, will begin in mid-Dec. and extend for several weeks