Ground-based Observations of Venus from Apache Point Observatory

Candace Gray
Support Astronomer
Apache Point Observatory

Nancy Chanover, Tom Slanger, Karan Molaverdikhani, Kerstin Peter, Bernd Häusler, Silvia Tellman, Martin Patzold, Oliver Witasse, Pierre-Louis Blelly, Glyn Collinson

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VEXAG Student/Young Career Travel Support
Outline

- Venus oxygen green line
- Aurora
- Solar Storms
- Ground-based observations
- Space-based observations
- Apache Point Observatory
Pourquoi?

- What is the driver behind Venus' oxygen green line?
- Probe the spaceweather-upper atmosphere interaction
- Atmospheric evolution
- Importance of ground-based observations
Aurora

- Variable
- Solar wind
- Charge particle precipitation
  - Electron impact
  - Ionization/excitation
Solar Storms

- X-class solar flares
  - Strongest flares
  - Brightest EUV emission
  - Nightglow
  - Short duration (min - hours)

- Coronal mass ejections (CMEs)
  - Plasma ejection
  - Aurora
  - 1 - 2 day arrival time
Keck, HIRES

Slanger et al. 2001
Apache Point Observatory

- 3.5m Astrophysical Research Consortium (ARC) Telescope
- ARC Echelle Spectrograph
  - High resolution
  - $R \sim 35,000$
  - 3500 – 10,000 Å
- Two 6-week windows / 2yr
- 2010 – 2015
Apache Point Observatory

- Importance of ground-based observations
  - Response time
  - Target of Opportunity
- Storm chasing

All day long, a tough gang of astrophysicists would monopolize the telescope and intimidate the other researchers.
Venus Express - VeRa

- Ionosphere
- Electron density profiles
- Dayside
  - Persistent V1 and V2 layers
  - Solar flux
- Nightside
  - Variable
  - Ion flow across terminator

Martin Pätzold et al. 2007
Venus Express - VeRa

- Changes in nightside V1 and V2 layer
- Decrease V2 electron density
- Increase in V1 electron density
- Is it real?

April 19 & 21, 2012  SZA =

Electron Density x 10^4 (cm^{-3})

Altitude (km)

557.7 nm detection
October 26, 2013

October 27, 2013

SZA = 162

After X-flare

October 29, 2013

SZA = 165

After CME
Science Conclusions

- Green line a unique aurora
- Most intense after large CMEs
- O + e likely source of green line emission
- Space-based observations show increase in:
  - Nightside V1 and V2 layers
  - Nightside electron precipitation flux and energy
- Made possible by ground- and space-based observations
Ground- & Space-based Coordinated Campaigns

- Fill in observation gaps
  - Temporal
  - Wavelength
- Confirm/compare observations
- Apache Point Observatory
Benefits of APO

- Easy to apply for time
  - Simple proposal process (1-3 paragraph science justification)
  - Time allocated in quarters
  - Applications due ~6 weeks before quarter
  - Fractional nights
- User friendly remote observations
Benefits of APO

- Flexible to changes (dates, instruments)
- We can “Martian” your needs
- User friendly remote observations
- BUT, need to be part of a member institute
APO Member Institutes

- University of Washington
- University of Colorado, Boulder
- New Mexico State University
- John Hopkins University
- University of Virginia
- Georgia State University
- University of Oklahoma
- University of Wyoming
- Leasing Partners
  - Adler Planetarium
  - Williams College
  - Bucknell
  - Colgate
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Instruments – IR

- **TripleSpec - Spectrograph**
  - 0.95 – 2.46 um
  - R ~ 2500 – 5000
  - Problems

- **NICFPS (Near-Infrared Camera & Fabry-Perot Spectrometer) - Imager**
  - 0.99 – 2.25 um (narrow & wide band filters)
  - FOV ~ 4.58' x 4.58'
Instruments – Visible Imagers

- **ARCTIC** (ARC Telescope Imaging Camera)
  - FOV ~7.5 arcmin
  - Plate Scale ~ 0.228 "/pixel, binned 2x2

- **AGILE**
  - High-speed time-series CCD photometer
  - Filters
  - FOV ~ 2.2 arcmin
  - Plate scale ~ 0.258 "/pixel
Instruments – Visible Spectrographs

- **DIS (Dual Imaging Spectrograph)**
  - \( R \sim 300 – 1200 \)
  - Variable wavelength centers
  - 5 filter imaging mode

- **ARCES (ARC Echelle Spectrograph)**
  - 350 – 1000 nm
  - High resolution (\( R \sim 32000 \))
Conclusions

- APO offers high quality science with versatility
- Interested in collaborations
- Make the proposal/observing process easy
Thank You!
Space-based Observations – VIRTIS

- Limb observations
- February 14, 2014 CME
- Green line detected from APO
- Lower limit of 5000 R