Hubble OPAL Observations of Uranus and Neptune: 2014-2019

Amy Simon
(NASA GSFC)
Michael H Wong
(U.C. Berkeley)
Glenn Orton
(Caltech/JPL)
**Hubble Outer Planets Atmospheres Legacy (OPAL) program**

- Yearly Hubble (UV-Vis) imaging of the outer planets; two global maps per planet, began in 2014 with Uranus, 2015 for Neptune and Jupiter, 2018 for Saturn

- Trend changes in:
  - brightness,
  - cloud activity,
  - 2D and zonal wind fields,
  - storm size, color, other changes
  - Serendipitous events

- All data are public,
- Maps are posted at STScI

https://archive.stsci.edu/prepds/opal/

Simon et al. 2015 ApJ 812, 55
Generated in 5 continuum filters:
- F467, F547, F657, F763, F845

2 methane absorption bands:
- F619, F727
Uranus

- Polar haze has continued to brighten
- Small storm activity

Toledo et al. 2019 Icarus 333, 1-11
Toledo et al. 2018 Geophys. Res. Letters 45, 5329-5335
Neptune

- It’s all about the storms!
- Hubble’s high spatial resolution at short wavelengths allows us to see dark vortices not otherwise visible
- New storm first seen in 2015 (SDS-2015)
- Moved poleward and dissipated by 2018

Wong et al. 2018 Astronomical Journal 155, 117
Another large storm found in 2018 (NDS-2018)
- Similar in size and drift rate as the Voyager Great Dark Spot, even though opposite hemispheres
- Data from prior years allows a look at cloud activity in the region over the preceding years
Long coverage allowed us to track likely pre-cursor clouds to this storm forming.

May be able to use shape to determine deeper atmosphere structure.

Simon, Wong & Hsu 2019 GRL 46, 3108-3113
Frequency and Lifetime of Dark Spots

- Counted dark spots seen by Voyager (2) and Hubble (4)
  - Time coverage is sparse, but maximum lifetimes could be constrained to 1 - 6 years
- Also looked at time coverage and how many observations had no spots detected
- Monte Carlo simulations then run to determine the likelihood of a spot forming, and of failing to detect it, based on these observing statistics
  - Can't see a spot, if not observing!

Hsu, Wong & Simon 2019 AJ 157, 152
Summary

- Seeing a lot of activity on both Ice Giants
  - **Uranus**
    - Smaller, high latitude, storms persist
    - Polar haze continues to brighten over time
  - **Neptune**
    - Two new dark vortices detected
    - Occurrence of a spot every 4-6 years, with lifetimes from 1 to 6 years
- Frequent observations are invaluable, but any future mission will see interesting atmospheric activity, regardless of timing
  - A Neptune orbiter with a lifetime of 6 years would be ideal for ensuring a dark vortex is observed