

IOPW Steering Committee Discipline Reports

Updated 2016-10-10 14:00

Include: Atmospheres, Satellites, Titan, and Aurora+Ionospheres Reports

Missing: Io, Pluto and Laboratory Measurement Reports

Meeting attended by:

Permanent Members: Bob West, Glenn Orton, Kunio Sayanagi

Discipline Chairs: Paul Steffes (Labs), Katherine de Kleer (Satellites, nominee replacement for Julie Rathbun),

Paul Corlies (representing Titan Alex Hayes), Andrew Steffl (Io Torus)

Rotating Members: Pat Irwin, Sarah Horst

Steering Committee Membership Update:

After the DPS 2016 meeting:

- Katherine de Kleer will replace Julie Rathbun as the Satellites Discipline Chair.
- Sarah Horst will replace Paul Steffes as the Laboratory and Theory Discipline Chair
- Jennifer Hanley jhanley@lowell.edu will replace Sarah Horst as a Rotating Member

Just to recap, post DPS-2016, IOPW Steering Committee members are:

Chair: Glenn Orton

Permanent Members: Imke de Pater, Chris Russell, Bob West, Heidi Hammel, Kunio Sayanagi

Rotating Members:

Aurora: John Clarke

Magnetospheres & Io Torus: Andrew Steffl

Atmospheres: Ricardo Hueso

Satellites: Katherine de Kleer

Lab and Theory: Sarah Horst

Titan: Alex Hayes & Paul Corlies

Uranus and Neptune: [Vacant]

Side note: Up to now, Heidi Hammel and Julie Rathbun have been the overlap between the steering committees of OPAG and IOPW – Kunio Sayanagi just joined the OPAG Steering Committee, and going to be the only overlap from here on.

The “main” IOPW Website is very outdated – needs updating:

<http://www-ssc.igpp.ucla.edu/IJW/>

IOPW Atmospheres Node Report (Ricardo Hueso)

1. Summarizing group work for the community (amateur and professional linking):

1.A. We have finalized the new version of the PVOL database of amateur observations of the Giant Planets. The new database allows more complex searches and will also host amateur observations of other solar system planets (Venus and Mars are useful for research). This database has been built as part of the Europlanet-2020

RI program funded by the European Commission. The new database hosts ALL previous data in the former PVOL database.

PVOL (new version): <http://pvol2.ehu.eus/pvol2/>

The new database is also searchable through the European VESPA (Virtual European Solar and Planetary Access) portal and uses the EPN-TAP protocol for searches.

<http://vespa.obspm.fr/planetary/data/epn/query/all/>

All in all we see a decline of observations by amateurs to the PVOL database. However there is an increasing number of very good observations submitted and the overall quality is improving. We suspect that most of the observers are not aware of the scientific value of their data. We expect to contact major amateur astronomical journals to publish a note about the new database and the scientific value of the observations.

2.A. A workshop with amateur astronomers was organized in Nice, France in May with funds from Europlanet-2020 RI. About 30 amateur and professional astronomers came together for two days and discussed about Jupiter observations in the frame work of Jupiter observations supporting Juno. Talks are available in:

http://www.ajax.ehu.es/Juno_amateur_workshop/

Attendees included Glenn Orton, Leigh Fletcher, Ricardo Hueso and well known amateur observers like Damian Peach or Christopher Go as well as representatives from ALPO Japan. A continuation of this workshop could be organized in London in 2017 by the British Astronomical Association with Europlanet-2020 RI funds for the amateur participants.

2. Group observational activities

We have run several observing campaigns with the Planetcam instrument over 2015 and 2016 mainly for Jupiter but also Saturn, Uranus and Neptune. This instrument allows to observe from 400 nm to 1.7 microns at high spatial resolution (0.1'' effective spatial resolution or better). It is generally used in the 2.2m telescopes in Calar Alto Observatory in Spain. Jupiter observations are reported in this workshop (5 observing campaigns) and Uranus and Neptune on 4 different runs from May to September have been used to monitor the atmospheric activity of both planets.

A new small telescope (36 cm aperture) has been installed in the Calar Alto Observatory to perform remote robotic observations of the giant planets frequently from Bilbao. One of the goals is monitoring Jupiter for impact events. The telescope is fully robotic and operable from Bilbao, 800 km away.

Reports for different planets follow:

Jupiter:

* Glenn Orton coordinates the ground-based observations in support of Juno. This includes HST (different instruments spectroscopy; Nichols; and images; Simon), VLT (several observations including MUSE, Irwin), Keck, Gemini, Subaru, Calar Alto 2.2m (Sánchez-Lavega)). He is also running frequent observation runs with the IRTF as well as collaborators (Greathouse, Fletcher). Amateur observations are coordinated through the Juno website and the Junocam project.

* A new small object hit the planet in March. Gerrit Kernbauer, an amateur astronomer from Mödling, Austria captured a video of Jupiter in which he observed a flash of light that lasted about a second. A second video of the same occurrence was captured by John McKeon from north Dublin, Ireland, who searched for the impact after news of this event. This happened on March 17, 2016 at 00:18:33 UT. Gerrit Kernbauer was using a telescope with an aperture of 20 cm and John McKeon a bigger 28 cm scope. The light-curve of this event has

not been analyzed but it looks very similar to previous events observed in July 2010, August 2010 and September 2012 and assumed to have been caused by objects of sizes in the range of 10 m.

* The PVOL database contains 1604 and 1425 observations of Jupiter in 2015 and 2016 submitted by amateurs. Many of these observations are submitted separately to the Juno mission website. The best observations are available on both sites. Some observers have been following Jupiter on day-light observations in order to provide support for Juno. John Rogers from the British Astronomical Association keeps updated notes on the morphology of the atmospheric systems over 2016. See for instance:

https://britastro.org/section_front/15

* We have run an analysis over these images that results in a zonal wind profile from amateur data with a precision of 10 m/s from +/-70 deg. This wind profile is not to the level of those obtainable from HST data from the OPAL program but is much better than previous wind profiles obtained from amateurs so that if any fast change would occur in the planet it could be measured with accuracy with the type of high quality data produced currently by amateurs.

Saturn:

HST observed Saturn on 3 orbits on 29, 30 June and 1 July 2015 (PI: Sánchez-Lavega). A report about equatorial winds from these observations will be published soon. A second report about polar activity is under preparation. The PVOL database contains 688 and 388 amateur observations of Saturn in 2015 and 2016. Many of them in both 2015 and 2016 can be used to observe a polar perturbation around the 72° jet close to the hexagon and a singular long-enduring feature at the Equator. Both phenomena have declined over 2016 or are less well observed this year.

Uranus:

Not much to report. Keck observed Uranus at least once in September 2016. The planet shows interesting activity but only small size clouds and the bright polar hood. Recent GranTeCan/CIRCE observations of Uranus might spot some of the features in the Keck images (these are discussed later with Neptune). Observations of Uranus by amateurs have been few (71 in 2015 and 17 in 2016) and monitoring of this atmosphere from amateur observations requires more collaborators (like in 2014 when a bright storm was observable by amateur observers).

Neptune:

HST observed Neptune twice this year. Observations in May (PI: Mike Wong) demonstrated the continuous presence of a dark spot (SDS-2015; Southern Dark Spot in 2015) first observed in HST/OPAL observations in 2015. HST observed Neptune a second time in October as part of the OPAL program (PI: Amy Simon). Observations are very recent but a first preview of the data shows many different cloud features, none of them apparently as bright as in 2015. A north tropical bright system is apparent and looking for the survival of the Keck observed the planet at least twice this year. Some Keck proposals that were awarded time could not be run due to bad weather. Neptune was observed in four different periods of time from May to September by the Spanish group with the 2.2m telescope at Calar Alto. They are also experimenting with new observations from GranTeCan with the CIRCE instrument (13 and 14 October) and a new AO system in the William Herschel Telescope in La Palma (15 October). Amateur observers have been very successful in capturing cloud features in Neptune this year. The best observations come from Australian observers that have Neptune very high in the sky. Also very good observations come from the Pic du Midi in observations by amateur astronomer Marc Delcroix in August. A comparison between all these varied datasets might be very useful to identify long-term changes between both HST observing runs this year and changes since 2015.

Discussion:

Subaru observation – Kasaba et al. has been observing Jupiter since last January using Subaru, which arguably has the best mid-IR camera, COMICS, for jovian imaging and spectroscopy, spatially resolved, data have been wonderful. According to James Sinclair, we had “splendid” two nights, polar vortices of Jupiter ... Observations to support PJ3, PJ4 (Feb 2nd) will slip into next semester.

IOPW Satellites Sub-discipline Report (Julie Rathbun)

Io Observations in 2016:

Observations of Io have continued at the same level as last year, with a major goal to compare volcanic eruptions to any changes in the Jovian magnetosphere or auroae as measured by Juno. Observations are ongoing. No major eruptions have yet been reported.

IRTF:

In Fall 2016 Julie Rathbun (with Spencer, and Tsang) observed Io’s volcanoes using direct observation and Jupiter occultations. They were also donated observing time in Spring 2016 from G. Orton. Have not presented any results.

In Spring & Fall 2016, Constantine Tsang (with Spencer, Greathouse, and others) continued his observations of Io’s atmosphere.

Keck:

In Fall 2016, Ashley Davies (with de Pater and de Kleer) awarded time to image Io’s volcanoes, but observations won’t start until January 2017. de Pater also had observations in late and upcoming in 2016.

Gemini:

Tsang and Katherine de Kleer continued observations of Io’s volcanoes, with 55 observations between February and June 2016. Will have more observations in late 2016.

In 2016, Observations of Europa have increased, both the surface and the near-surface to search for plumes.

Sparks et al. published HST observations of Europa (from 2014) in front of Jupiter, finding dark areas just off Europa’s limb, interpreted to be absorption of Jupiter’s light by plumes.

Lucas Paganini obtained Keck/NIRSPEC observations of Europa in order to search for Gaseous Plumes. Results presented at DPS.

In 2015, Tracy Becker (with Retherford, Hanley, Greathouse, Tsang, and Roth) observed mid-IR spectra of Europa with IRTF/TEXES searching for salt signatures. Presented at 2016 DPS.

Observations of other satellites: Triton

Spring 2016, a group led by Leslie Young began observing Triton from IRTF. This appears to be a restart of an observing campaign by Will Grundy in the early 2000s and others even before that (TritonWatch program).

Discussion:

Mostly three moons have been studied for the past year: Io, Europa and Triton as summarized above. Io observation has been done by the same group who have been looking at Io.

Europa is observed this year by a new group led by Tracy Becker, looking into using IRTF TEXES to look for salt signatures.

Triton – anybody doing IRTF observations? Leslie Young and co have observation from early 2000s.

ALMA was used to look at Triton, unknown PI.

ALMA was used to look at Enceladus, unknown PI.

K2 time to see Titan and Encelladus, December and January (who's the PI?).

ALMA to look at Europa, Ganymede, and Callipso – de Kleer was the PI.

IOPW Io Plasma Torus sub-Discipline (Andrew Steffl)

Update October 2016

Most of the activity in the past year related to the Io plasma Torus sub-discipline has focused on the Japanese mission, Hisaki. The EXCEED FUV spectrograph on Hisaki continues to make observations of the Io torus and Jovian aurora, and the mission has been officially extended until the end of the Juno prime mission. To my knowledge, there have not been any new ground-based observations of the Io torus in the past year, although Mizuki Yoneda and Masato Kagitani are continuing their observations monitoring the brightness Io's extended sodium clouds.

In response to the call in the last ROSES, NASA has selected Fran Bagenal, Peter Delamere, Daniel Santos-Costa, Nick Schneider, Todd Smith, and Andrew Steffl to be Hisaki-Guest Investigators. Hisaki-GIs receive travel support from NASA for up to 3 trips to Japan to collaborate with Hisaki team members. Notably, Hisaki-GIs must be self-supporting, as the program does not include any funding for labor costs.

Hisaki data have now been placed in a publically accessible online archive: <http://darts.isas.jaxa.jp/pub/hisaki/> Please read the "Rules of the Road" document if interested in using the data. The expectation is that a data analysis program in the forthcoming 2017 ROSES call will explicitly allow proposals to analyze Hisaki data.

To aid those who are new to the field or not fully aware of previous research on the Io torus and Jovian magnetosphere, Fran Bagenal, has created an extensive online bibliography of torus-related publications. In addition to the bibliographic information, Fran has specified which set of atomic physics data (emission rate coefficients, etc.) each paper used and provided a brief summary of each paper's major findings. The bibliography can be found at: <http://lasp.colorado.edu/home/mop/bibliographies/> A list of Hisaki-related publications can be found at: <http://www.isas.jaxa.jp/home/sprint-a/txt/publications.txt>

Upcoming Meetings:

A Hisaki Workshop will be held during the AGU Fall Meeting in San Francisco, Monday December 12th from 2pm to 5pm. The location is still TBD. Contact Fran Bagenal for more information. In addition, a more extensive Hisaki/ Io plasma torus workshop is being planned for mid-January (tentative dates Tuesday, Jan. 17th to Friday, Jan. 20th) in Boulder, Colorado. The focus of this workshop will be on analysis of Hisaki torus observations, modeling Io torus physical chemistry, and comparing the Hisaki data and models - plus

comparison with ground-based observations. Hot electrons (their characteristics as well as sources & transport), temporal and spatial variations - as well as the ratio of total oxygen to total sulfur species - will be central topics. The next MOP meeting will be held 12-16 June 2017 in Uppsala, Sweden.

New Publications:

Bagenal, F., Sidrow, E., Wilson, R.J., Cassidy, T.A., Dols, V., Crary, F.J., Steffl, A.J., Delamere, P.A., Kurth, W.S., and Paterson, W.R., doi:10.1016/j.icarus.2015.07.036, 2015, Plasma condition at Europa's orbit, Icarus, 261, 1-13.

Copper, Delamere, Overcast-Howe, 2016, Modeling physical chemistry of the Io plasma torus in two dimensions, J. Geophys. Res., 121

Tsuchiya, F., et al., 2015, JGR:Space Physics, doi:10.1002/2015JA021420. Local electron heating in the Io plasma torus associated with Io from HISAKI satellite observation

Yoneda, M., et al., 2015, Icarus, doi:10.1016/j.icarus.2015.07.037. Brightening event seen in observations of Jupiter's extended sodium nebula

Discussion

Biggest development by far in the discipline is Hisaki/EXCEED – still in operation, excellent sc health, papers are starting to come out. No special issue on journals, but papers are coming out piecemeal, lots of good work. Hisaki/EXCEED also extended to support Juno mission, best companion for Juno. EXCEED, system overview, monitor whole-time through Juno time. Hisaki mission extended beyond Juno timeline.

Hisaki – UV spectrograph. 500A to 1400A, coarse emission lines and Aurora. 24/7 for half a year to look at Jupiter. They are starting to put data on public archive, encourage collaborators. Hisaki Guest Investigators, Fran B, Nick S. Andrew S. Peter Smith, Daniel Santos Costa, Todd Smith – no money attached to the program, only travel money. Couldn't figure out process to provide funding. Next ROSES call will have funding for explicit data analysis tasks. Hisaki data calibrated, posted on public archive.

Working workshops upcoming – at AGU and Boulder, discuss, people working on Torus research and Hisaki, contact Fran Bagenal.

Brazil Meeting – we had in April – Imke de Pater and others invited, coordinate broader Jupiter science, what are the volcanos on Io doing to the torus, focused workshop – Brazil seems to be trying to come out into the international scenes. Couple of people doing not Volcanoes ... Earth Aurorae ... they have done Io aurora, moving toward that area.

Ground-based obs. ... Apache Pint Obs. .. upcoming observations there.

Jeff Morgenthaler (PSI) – NSF funding to build a dedicated telescope for torus observation. 1-m class. 20-inch, 30-inch.

Titan Observations from 10/2015-10/2016

Paul Corlies and Alex Hayes

Past Observations

- NIRI – 8 epochs from February through May designed as best as possible to have targeted observations during Cassini flybys
- IRTF – 41 epochs in 2016 spread evenly over the course of the year. These were designed to look for whole disk variations of cloud activity. To date, none has been observed.
 - We had simultaneous observations with anomalous Cassini observations in June 2016 where a cloud was observed in VIMS but not ISS. It was also not observed from the ground. Our best guess to date is that this was an optically thin cloud, which was more sensitive to the VIMS instrument at longer wavelengths.
- ALMA – One observation on 12/2016 by Sandrine Vinatier to look at the nitrile/oxygen chemistry in Titan’s middle atmosphere. One observation by Connor Nixon in 07/2016 to look pyridine/pyrimidine in Titan’s atmosphere.
- Cassini Weather– Cassini has had 10 close flybys of Titan and 7 distant flybys in the past year. In addition there has been 61 TMC observations. From 01/2016-07/2016 small clouds have regularly been observed at mid-high northern latitudes in the Cassini dataset. No clouds have been observed since the end of July 2016.
- Cassini RADAR – there were two closest approach radar swaths over the past year. T120 (June 2016) targeted mid-high southern latitudes, while T121 (July 2016) targeted equatorial latitudes.
- Keck – One observation on April 30th with NIRSPA0 for follow up observations on measuring the meridional dependence of the methane fraction in Titan’s atmosphere.

Upcoming Observations

- Proposed time on VLT/SINFONI, Gemini/NIRI, and IRTF/Spex to continue the ground based efforts for tracking meteorology. These are especially timely given the end of the Cassini mission, and act as our last chance to ground truth cloud observations in the north. We will also continue Fast Turnaround/DDT proposals, as needed, to compliment scheduled Cassini encounters.
- Cassini Weather – there are 18 scheduled encounters of Titan until the end of the Cassini mission. 3 are close flybys ($\sim 10^3$ km approach) and 15 farther encounters ($\sim 10^5$ km) spaced roughly every two weeks. These encounters focus largely on equatorial/high northern latitudes. Further, continued short TMC observations (22 planned) will be interspersed, when possible (with a range as far as $2 \cdot 10^6$ km).
- Cassini RADAR – there is one final closest approach RADAR observation planned for T126 – the final close flyby of Titan in April 2017.
- ALMA – there are currently three nights of observing scheduled for Mark Gurwell for high resolution mappings of Titan’s atmospheric components in the submm and to trace dynamics (measuring winds from 300km-900 km) and temperature between 600km-900km.

Discussions

Starting from non-radar stuff – from the ground – Mate Adamkovics + Imke de Pater have been using Keck to look at latitudinal variation in the Methane abundance ... they’ll continue their work on Keck.

ALMA – two public release, June-July, composition of Titan Atmosphere ... small cyclic molecules, band 6 ...

This past year, IRTF+ Gemini made 40 observations of Titan, looking for clouds on Titan, but nothing has been seen from the ground – we are having problem with scattering from the north pole, making it difficult to find clouds from the ground. From Cassini, VIMS and ISS have found clouds, but nothing since July ... we haven’t seen clouds in ISS, T120 clouds seen on VIMS Optically thick clouds, obscured by hazes?

Upcoming – Gemini. IRTF, VLT, simultaneous with Cassini – looking for ground truth to validate ground-based obs. Continued from Cassini ... three more flybys ... RADAR prime flyby next ...

In-progress ALMA proposal ...

Nick Teamby – ALMA proposal, not executed yet.

One more thing – ALMA always looks at Titan as a calibration target – if they can modify the calibration observations, they are going to continue to use Titan for cal ... may be people should sit down to see how we can make these observations more useful – for example, 10sec more time will make data more useful. This applies to Uranus, Neptune, Ganymede. Community push might be needed.

How do we approach ALMA? We should think it a bit more first about benefits. ALMA has been used by Arielle Moullet. Brian Butler also helped ALMA solar sys ... interesting things ... line strength itself isn't that interesting, but comparison between the hemisphere would be for example.

IOPW Aurora and Magnetosphere sub-Discipline (John Clarke)

Update Oct 2016

There has been a high level of effort in the past year on observations of Saturn, owing to the continuing Cassini mission and the approaching end of the Cassini mission. There has been a two-year HST observing program of Saturn's aurora led by L. Lamy and S. Badman toward this goal, and a concentrated series of auroral images have been obtained over 2016 in this program. There have also been some ground-based observations of the H3+ ionospheric emissions from Saturn in support of the final year of the Cassini mission. A set of papers in volume 263 of *Icarus* has covered a range of topics in the joint observations of Saturn's aurora, see references below.

In addition there have been two large HST observing programs devoted to coordination with the JUNO mission arrival and orbit insertion at Jupiter. The first program in the last HST cycle made observations of Jupiter's aurora while JUNO was measuring the solar wind on its approach to Jupiter, a program led by J. Nichols. In the present cycle of HST starting in Fall 2016 a larger program led by D. Grodent will obtain auroral observations during the prime JUNO mission, concentrating on measuring the global auroral activity at key times in the JUNO spacecraft orbit about Jupiter. The Japanese EXCEED instrument on the HISAKI mission is also operating, and returning observations of the Io plasma torus and jovian aurora. In addition numerous ground-based observing programs are in place in support of the JUNO mission, including observations of the ionospheric emissions of H3+ from Jupiter. These Jupiter programs are in the early stages, with published results expected in the future.

The status of the discipline was reported at the July 2015 Magnetospheres of the Outer Planets conference, held in Atlanta GA (<http://mop.gatech.edu/>). The next MOP meeting will be over 12-16 June 2017 in Uppsala Sweden.

New Publications:

“Saturn's Northern Auroras as Observed Using the Hubble Space Telescope”, J.D. Nichols, S. Badman, E. Bunce, J.T. Clarke, S. Cowley, G. Hunt, and G. Provan, *Icarus*, 263, 17-31, doi: 10.1016/j.icarus.2015.09.008 (2016).

“Saturn Kilometric Radiation Intensities during the Saturn Auroral Campaign of 2013”, W.S. Kurth et al., *Icarus*, 263, 2-9, doi:10.1016/j.icarus.2015.01.003 (2016).

“Simultaneous Multi-scale and Multi-instrument Observations of Saturn’s Aurorae during the 2013 Observing Campaign”, H. Melin et al., *Icarus*, 263, 56-74, doi:10.1016/j.icarus.2015.08.021 (2016).

“A Multi-scale Magnetotail Reconnection Event at Saturn and Associated Flows: Cassini/UVIS Observations”, *Icarus*, 263, 75-82, doi:10.1016/j.icarus.2014.12.016 (2016).

“Saturn’s Auroral Morphology and Field-aligned Currents during a Solar Wind Compression”, *Icarus*, 263, 83-93, doi:10.1016/j.icarus.2014.11.014 (2016).

“The Color Ratio-intensity Relation in the Jovian Aurora: Hubble Observations of Auroral Components”, J.-C. Gerard, B. Bonfond, D. Grodent, and A. Radioti, *Plan. Sp. Sci.*, 131, 14-23, doi:10.1016/j.pss.2016.06.004 (2016).

“The Impact of an ICME on the Jovian X-ray Aurora”, W.R. Dunn et al., *J. Geophys. Res.*, doi:10.1002/2015JA021888 (2016).

“Weakening of Jupiter’s Main Auroral Emission during January 2014”, S.V. Badman et al., *Geophys. Res. Lett.*, doi:10.1002/2015GL067366 (2016).

“Characteristics of North Jovian Aurora from STIS FUV Spectral Images”, J. Gustin, D. Grodent, L. Ray, B. Bonfond, E. Bunce, J. Nichols, and N. Ozak, *Icarus*, 268, 215-241, doi:10.1016/j.icarus.2015.12.048 (2016).

“Stability Within Jupiter’s ‘Swirl Region’ over Moderate Timescales”, T.S. Stallard, and 10 co-authors incl. J.T. Clarke, *Icarus*, 268, 145-155, doi: 10.1016/j.icarus.2015.12.044 (2016).

“A Model of Force Balance in Jupiter’s Magnetodisc Including Hot Plasma Pressure Anisotropy”, J.D. Nichols, N. Achilleos, and S. Cowley, *J. Geophys. Res.*, doi:10.1002/2015JA021807 (2016).

Paul Steffes (Lab) reports

Working on preparing data for Juno – it is interesting because the mission senses radiation from atmospheric layer of 1000s of bars, 800-900K temperature -- simulating that in Lab is hard. So we are trying our best to do physical modeling to validate the lab measurements up to 600 K in 100 bars – that’s been the focus for the couple of months.

Others – there is work in progress to support Jovian satellites, but list hasn’t been populated.

What other work is necessary? Identifying needs:

Exoplanet community generated a list of experimental needs for their community, published on arXiv, community generated list of measurement needs. Sarah is on CAPS (Committee on Astrobiology and Planetary Sciences), needs for returned samples, there are discussions about how we are supporting labs.

Action item – community-endorsed list of needed measurements will be useful. First step: Ask ROW people if they identified lab measurements. One of the major findings of ROW is that we don’t know the properties of

Ices that are found on these satellites. Go through OPAG to reach out to the community. Get hints from the Exoplanets list – what they do is probably useful for us as well.

The Exoplanet arXiv paper – Sarah Horst will send a link to the group.

Broader library of FUV reflected spectra – interesting things tend to gunk up vac chambers.

Hydrogen atmosphere thermal/dielectric properties of gas – we don't know of any atmospheres that have any magnetizable material. Inductors should be okay. Capacitors – refractivity, dielectric constant of the atmosphere is well-known – it can be well modeled, bulk properties are known – NIST does have those numbers, someone wants to spend time to dig through.