INFRARED SCIENCE INTEREST GROUP

No. 6 | August 2021

Contents

Follow us on Twitter!

@ir_sig

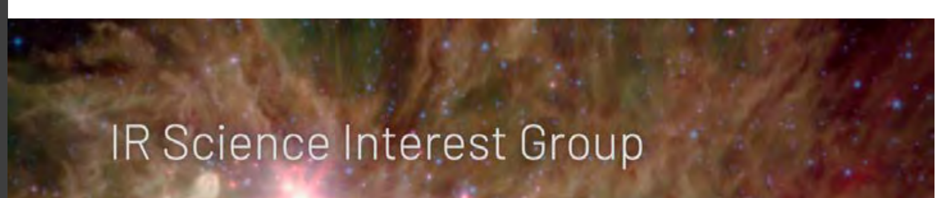
From the IR SIG Leadership Council

From the IR SIG Leadership Council

As life starts to get back to normal, the outlook for space-based IR Astrophysics and Astronomy looks very positive. Exciting new results from suborbital missions, SOFIA, and ALMA continue to be released, while work continues on important projects in development like JWST, SPHEREx, and a variety of balloon missions. We anticipate that the Decadal Survey will be released imminently. As we look optimistically to the post-COVID world, we expect new challenges but also exciting new opportunities. Though perhaps not the largest among these, we want to note that we are currently inviting applications to join the IR SIG. Leadership Council – please contact us for more information if you'd like to get involved!

The SIG's primary mission is to collect community input, foster consensus, and help shape the long-term goals of IR astrophysics. Our main priority is to reach out to the community spanning the entire IR wavelength range, including users of current facilities like SOFIA, ALMA, and the range of suborbital platforms, as well as upcoming observatories like the *Webb* and *Roman* Telescopes. This semi-annual newsletter is a part of this effort highlighting results, technological developments, and events from the IR community. We encourage contributions describing interesting, unique, and important science and technology breakthroughs from all of our readers. Throughout the year, we will also continue to host a monthly webinar series (https://cor.gsfc.nasa.gov/sigs/irsig.php) and an annual splinter session at the winter AAS meeting. We encourage members of the community to get involved with the IR SIG and remain dedicated to ensuring our activities reflect the needs of our community, stakeholders, and early-career scientists of diverse backgrounds.

Sincerely,
IR SIG Leadership Council



Workshop Report "IR SIG Splinter Session: Adapting to Uncertain Times" at the 237th American Astronomical Society Meeting

Michael Zemcov[1] & Meredith MacGregor[2]
on behalf of the Infrared Science Interest Group (IR SIG)

[1] Rochester Institute of Technology
[2] University of Colorado Boulder

The IR SIG organized a splinter session entitled "Adapting to Uncertain Times" during the American Astronomical Society (AAS) winter meeting held virtually in January 2021. The primary goal of the meeting was to discuss what we, as a community, can do to advocate for ourselves and ensure continued access to platforms and missions that will keep the future of IR astrophysics as vibrant and productive as it has been over the past 20 years. Although the outcomes of the decadal review have yet to be heard, the view beyond JWST for IR astrophysics looks unsettled. Strong science cases, technology development, and community advocacy can help ensure that we will have opportunities to deliver on the scientific potential inherent in the field.

The session began with a brief address from Peter Kurczynski, the incoming Chief Scientist of NASA's Cosmic Origins Program, during which he laid out a vision for a more active Science Interest Group structure that will be developed over the next few years. Following this, four invited speakers gave their response to the questions posed by the IR SIG:

1. *Considering the current state of astronomical IR science and technology, how do you see the next decade or so unfolding?*

2. *What are the investments we as a community can make now that will pay large dividends in the future?*

Alex Pope (UMass) and Ted Bergin (UMich) began by giving their responses from the science perspective, highlighting science cases related to extragalactic, galactic, and exo-planetary science that will drive the science of the next decade. Prominently featured were spectroscopic probes from the near-IR well into the sub-mm that will allow us to understand structure, chemistry, and evolution of a wide range of astrophysical phenomena. Next, Jason Glenn (GSFC) responded to the questions posed from the point of view of technology development and advancement. He pointed out that NASA's current funding model for technology development, which is typically capped around 3 years, does not sustain efforts over periods long enough to mature new IR technologies to high Technology Readiness Level (TRL), which typically requires decade-long timescales. Crucial technology gaps for future missions include high efficiency optics and filters, and high efficiency miniature cryocoolers, particularly for balloon and explorer missions. Finally, Rachel Akeson (JPL/IPAC) discussed ways to improve community involvement and advocacy. An important component of our efforts should be to recruit more early-career and underrepresented scientists into IR instrumentation to ensure the community remains vibrant into the future.

Following the invited talks, all attendees were invited to move to an open virtual forum where the following five questions were available for discussion:

1. *If you could design a 2027-launch MIDEX-class mission to answer the most pressing questions in our field, what would it look like, assuming no dramatic leaps forward in technology?*

2. *If you could magically have a factor of ten improvement in one of: sensitivity, spatial resolution, spectral resolution, wavelength coverage, or dynamic range over what is currently possible, what would you pick and why?*

3. *What are our next steps after JWST? Assuming OST is not a slam-dunk at the decadal, should we focus on building smaller suborbital and explorer-class missions, or should we aim for a flagship mission?*

4. *Are there areas/ways where we, as an IR community, could expand/interface with communities that don't traditionally turn to IR for their science? Are there ways to expand our community and pool resources that aren't currently being exploited?*

5. *Which area of research has the most to gain from a space-based (far)-IR mission, and what is the most important scientific discovery that would result? What is the greatest discovery waiting to be made in IR astrophysics?*

Participants were invited to circulate around and discuss any questions of interest in a group setting. Highlights from the community discussion included potential science topics of relevance to future IR NASA missions:

- Understanding the habitability of exo-planets, including finding/characterizing planets in habitable zones, searching for biosignatures in the infrared (i.e., water, methane, and ozone), surface temperature determinations, measurements of protoplanetary disks and planet formation traced by mid-IR line (e.g., hydrogen deuteride) brightness, spatial structure, and velocities;

- Observations of of interstellar matter traced by cold, low-excitation dust, including its production and effect on galactic feedback and dynamics;

- Studies of super massive blackholes, including the relationship between star formation and black hole growth, and the evolution of this relationship over cosmic time;

- Measurements of high-*z* galaxies, particularly the evolution of their metallicity and chemistry, and how and when dust grains form and change over time.

There were also discussions of issues related to technology development and engineering for missions to support these science cases. Some points of interest included:

- Cryogenic development remains a limiting technology gap and the community agrees that more funding opportunities to develop low-TRL solutions are crucial to enabling Explorer and smaller-class IR missions.
- Detector technology remains important for improving the sensitivity of all classes of FIR mission. In particular, there is a significant technical gap between the current laboratory-demonstrated Noise Equivalent Power (NEP) of 10^{-19} W $Hz^{-½}$ and the desired spectroscopy requirement of 10^{-20} W $Hz^{-½}$.
- Aperture size remains a limiting factor for single-mirror instruments.

Discussions related to community engagement and growth also had some interesting highlights:

- As in the past, it was noted that the future of IR astrophysics is dependent on engagement of the larger astrophysical community; support from a wide range of astrophysical science is necessary for a realistic chance at an IR flagship or probe-class mission. Further, continued advocacy and engagement are important to keep any opportunity that is allocated moving forward.
- In the short term, JWST will attract a wide range of multi-wavelength astrophysicists, many of whom already or soon will understand the utility of IR observations.
- Even if something like OST is endorsed in the future, we will still need smaller, more focussed missions to keep the astrophysics community engaged in the mid-term.
- However, reaching beyond the JWST community will require presence in non-IR spaces, including: highlighting concrete results rather than possible achievements; being as flexible as possible about platforms for IR science, including SmallSats and sub-orbital vehicles; leveraging commonalities in science and technology; and developing tools and workshops to allow engagement of the wider community.

At the conclusion of the meeting, the consensus was that our community should meet again after the Decadal Review is released to discuss the impact of their assessments. As a result, the IR SIG is planning to have a meeting in Autumn 2021 devoted to understanding the Decadal Review and discussing how we as a community might achieve our science, technology and community goals over the next 5 years. This workshop will be fully virtual and will be advertised for open community registration as soon as the Decadal Survey release date is known.

Disintegrating Planet is Ejecting A Massive Dust Tail with Large Grains

Everett Schlawin

University of Arizona

***Paper**: LBT Reveals Large Dust Particles and a High Mass Loss Rate for K2-22b*
Schlawin, E., Su, K.Y.L., Herter, T., Ridden-Harper, A., Apai, D.
Astrophysical Journal, accepted (2021). arxiv.org/abs/2106.07648

The disintegrating planet K2-22 b is ejecting large dust grains at a precipitous rate, meaning that its remaining lifetime may be as small as 21 Myr. The tail of debris was observed with the Large Binocular Telescope (LBT) and Hereford observatory to have dust particles larger than 0.5 microns in radius and a mass loss rate of 3e8 kg/s, equivalent to about 170 times the flow rate at Niagara Falls. The short remaining lifetime suggests there may be a hidden population of small planets that are progenitors for K2-22 b and similar disintegrating systems.

Beginning with the discovery of Kepler-1520 b by Rappaport et al. 2012[1], a small handful of planets are known that are disintegrating and spewing dust tails. These dust tails produce a characteristic lightcurve that is asymmetric due to the long tail of dust either trailing or leading a planet. They also exhibit wild variations in transit depth or amount of starlight they extinct, ranging from 0% to a little over 1%.

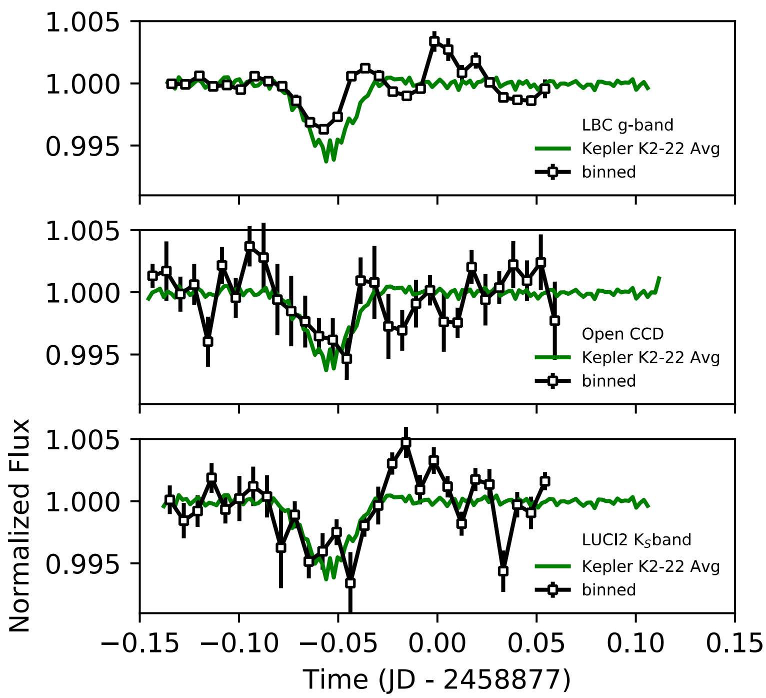
The mechanism that destroys these planets is not entirely known but is well explained by an escape model where the rocky surface is sublimated to make a metal-rich vapor atmosphere that can escape hydrodynamically from the gravitational pull of the planet. Another mechanism that has been proposed is explosive volcanism, but K2-22 b's mass loss rate is five orders of magnitude higher than the Solar System's most volcanically active body, Io. The hydrodynamic model also explains some of the variability seen in K2-22 b's light curve such as alternating deep and shallow transit features.

One of the avenues to explore disintegrating systems is to study the wavelength dependence of the dusty effluents from the planets. As explained by Mie theory, the dust should be relatively transparent to long wavelengths from the star, so longer infrared measurements constrain the size of the debris.

Ground-based observations can be used to compare the transit depths of the systems in the optical and near-infrared. It is important that the optical and near-infrared observations occur simultaneously because these disintegrating systems are wildly variable and erratic, so they can have transit depths of near 0% to 1% just one orbit later, so non-simultaneous measurements are difficult to compare. The Large Binocular Telescope is well suited to make multi-band observations using one 8 m mirror to gather a lightcurve at visible wavelengths (0.48 um) and the other 8m mirror to gather a lightcurve in the K band

[1] https://ui.adsabs.harvard.edu/abs/2012ApJ...752....1R/abstract

(2.1 um). The team also paired with a local amateur astronomer Bruce Gary of the Hereford observatory to gather photometry with an unfiltered CCD for an intermediate wavelength band.



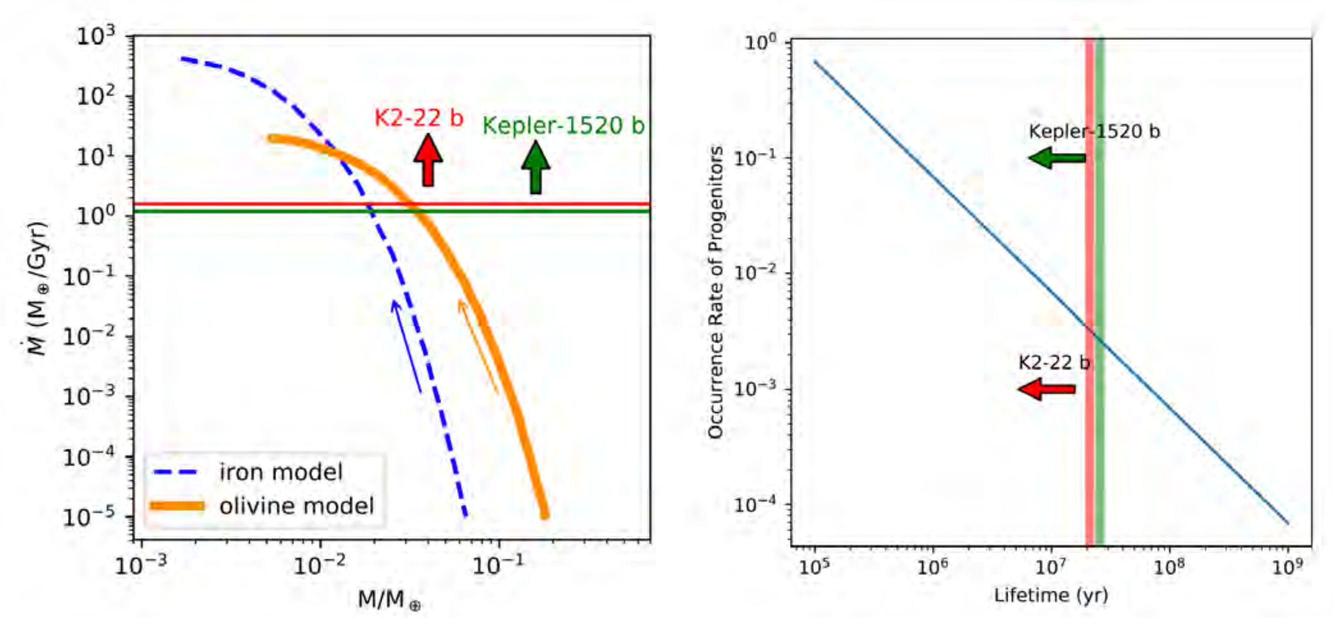
Photometry from UT 2020-01-28, where there was a medium-depth transit. The 82 day average lightcurve from K2 is scaled to best-fit the data.

During one transit observation, the transit depths between the 0.48 um and 2.1 um were equal within errors. This indicates that the median particle sizes must be larger than 0.5 microns, assuming they are made of pure iron and 1.0 microns if they are made of quartz. This is just a lower limit so even larger grains are possible. The large size of the grains, coupled with the fact that they cover about half a percent of the star, means that the total mass of dust is significant (more than 1.3e13 kg). Finally, the fast variability of the system tells us that it is created and cleared at a rate of 3e8 kg/s.

High precision lightcurves of K2-22 b during one of the nights of observation showed no evidence of a transit. While not helpful for studying the dust, this can constrain the size of the underlying planet. The LBT lightcurves indicate that the size of the planet must be less than 4500 km. Hydrodynamic models predict that it is significantly less massive at 0.03 earth masses. Putting this small size together with the fast mass loss rate of debris indicates that K2-22 b has less than 21 million years remaining.

If K2-22 b and its disintegrating cousins have short lifetimes of tens of millions of years, they are unlikely to be detected by random chance. However, more than 2 periodic disintegrating systems have been observed to orbit main sequence stars in the primary Kepler mission and 1 in K2. Putting together the geometry of the orbit and the total number of stars observed, there must be a progenitor to a disintegrating planet in more than 0.3% of stars. Thus, there is likely a population of planets that are Mercury-sized or smaller that can be discovered by transit surveys with higher precision than Kepler.

Future observations in the infrared will give further insights into disintegrating planets and their dusty debris. There are prominent spectral signatures from rocky material that appear in infrared spectra. Someday with JWST and the MIRI instrument, it may be possible to distinguish rocky materials such as iron, quartz or other materials. This could tell us whether K2-22 b is a terrestrial planet surrounded by a crust, mantle or core-like material and whether it is nearing the end state of a once-larger planet.[i 2]



Left: The mass loss rate trajectories as a function of mass from hydrodynamical models (Perez-Becker & Chiang 2013) are indicated for an olivine composition planet and an iron composition planet in orange and blue, respectively, with arrows indicating the direction of evolution. The high mass loss rates for K2-22 b and Kepler 1520 b (with lower limits shown as horizontal red and green lines, respectively) imply that the underlying planets are in their final catastrophic state of evolution. Right: Given the short lifetime of the systems (with upper estimates shown as vertical lines for K2-22 b and Kepler 1520 b, respectively), we expect that short-period small progenitors may be common in more than ~0.3% of systems.

[1] https://ui.adsabs.harvard.edu/abs/2020ApJ...901..171O/abstract
[1] https://ui.adsabs.harvard.edu/abs/2018AJ....156..173B/abstract

The CIBER-2 Sounding Rocket Experiment Successfully Completed First Flight

Chi Nguyen

Rochester Institute of Technology, California Institute of Technology

The second Cosmic Infrared Background Experiment (CIBER-2) was first launched on a recoverable Black Brant IX sounding rocket on June 7, 2021. A collaborative effort between institutions in the US, Japan, and South Korea, the mission leverages intensity mapping to investigate the extragalactic background light (EBL) at 0.5 - 2.0 μm.

The EBL comprises emissions from all sources outside of the Milky Way. The optical/near-infrared (NIR) EBL (<10 μm) originates primarily from stellar nucleosynthesis and traces the history of star formation back to the Epoch of Reionization at redshifts $z > 6$. Observations of the EBL and its large-scale fluctuations (~arcminute) place tight constraints on the models of structure formations and complement galaxy surveys by probing the faint populations below survey detection limits. Multiple EBL studies using data from the first-generation CIBER-1 and *Spitzer*/IRAC, among others, suggest that the NIR EBL fluctuates more than expected. The excess may imply unaccounted sources or modifications to the models of structure formation. CIBER-1 results can be explained by intrahalo light (IHL) from faint stars at the edge of galaxies at $z < 6$. However, CIBER-1 lacked the sensitivity and the spectral coverage to disentangle the IHL from the EBL.

Experiment team from RIT and Caltech in front of the Black Brant IX carrying CIBER-2 at the White Sand Missile Range, New Mexico. Photo by NSROC/WSMR.

To distinguish the high-redshift EBL components from the IHL, the second-generation CIBER-2 design takes advantage of the fact that $z > 6$ sources contain a unique absorption feature at rest-frame wavelength shorter than the Lyman limit (also known as the Lyman break). This break is now redshifted to wavelength >= 1 μm. CIBER-2 uses 6 wavebands covering 0.5 - 2.0 μm, with two wavebands at < 1 μm where we expect to see only IHL and no EBL. To decompose the EBL and IHL, we apply a multi-component separation technique that incorporates the sky power spectra at all 6 wavebands.

CIBER-2 comprises a Cassegrain 28.5-cm telescope with 2deg x 2deg field of view and three state-of-the-art HAWAII-2RG detectors - similar to those on the *James Webb Space Telescope* and the *Nancy Grace Roman Space Telescope*. To simultaneously collect data at 6 wavebands, each detector is coupled with a dual-band windowpane filter. Additionally, the detectors are equipped with linear variable filters (LVF) for absolute EBL spectrophotometry. As one of the first astrophysics missions to demonstrate the HAWAII-2RG in space, CIBER-2 provides invaluable data to quantify the detector performance and helps develop analytical tools for future missions using similar LVF technology like SPHEREx.

CIBER-2 integration with RIT and Kwansei Gakuin University (Japan) team at the Wallops Flight Facility, Virginia. Photo by NSROC/WFF.

CIBER-2 was integrated at the NASA Wallops Flight Facility, Virginia. The first flight took place at 00:25 MST on June 7, 2021 from the White Sand Missile Range, New Mexico. The payload achieved an apogee of 325 km above sea level with approximately 400 seconds of science time. Telemetry downlink confirmed that the HAWAII-2RG detectors functioned as designed throughout the entire flight. After payload recovery, data were successfully recovered from the on-board hard disk drives and are currently being analyzed. The payload will be refurbished for three more flights.

Related papers

Design:

https://ui.adsabs.harvard.edu/abs/2014SPIE.9143E..3NL/abstract
https://ui.adsabs.harvard.edu/abs/2016SPIE.9904E..4JS/abstract
https://ui.adsabs.harvard.edu/abs/2018SPIE10698E..49P/abstract

Characterization and integration:

https://ui.adsabs.harvard.edu/abs/2018SPIE10698E..4JN/abstract
https://ui.adsabs.harvard.edu/abs/2020SPIE11443E..5AT/abstract

CIBER-1 latest science result: - Stacking analysis from the 4th flight:

https://ui.adsabs.harvard.edu/abs/2021arXiv210303882C/abstract

Measuring the Zodiacal light using CaII Fraunhofer emission line**:**

https://ui.adsabs.harvard.edu/abs/2021arXiv210407104K/abstract

Payload recovery. Photo by NSROC/WSMR.

UPCOMING EVENTS

4-7 Aug 2021 NRAO Science Meeting – The Past, Present and Future of the VLA: Celebrating 40 Years – **ONLINE**
https://go.nrao.edu/vla40

23-26 Aug 2021 Gemini Observatory 2021 Virtual Science Meeting – **ONLINE**
https://noirlab.edu/science/resources/meetings/gsm2021

23-25 Sept 2021 Maria Mitchell Women of STEM Symposium – **ONLINE**
http://www.mmwss.org/

13-21 Sept 2021 Single Dish Observing School, Presented jointly by the Green Bank and Arecibo Observatories – **ONLINE & Green Bank, WV**
https://greenbankobservatory.org/science/gbt-observers/single-dish-training-workshop/

5-6 Oct 2021 McGill Bicentennial Space Research Conference – **Montreal, Quebec**
https://www.cadc-ccda.hia-iha.nrc-cnrc.gc.ca/en/meetings/getMeetings.html?number=6432

3-7 Oct 2021 Dark and Quiet Skies for Science and Society II – **La Palma, Canary Islands**
http://research.iac.es/congreso/quietdarksky2021/pages/home.php

21-29 Oct 2021 NYRAI (Network of Young Researchers in Instrumentation for Astronomy) Workshop 2021 – **ONLINE**
https://nyriastronomy.github.io/workshops/2021/

15-19 Nov 2021 Supervirtual 2021: From Common to Exotic Transients – **ONLINE**
https://sites.google.com/view/supervirtual2021/ – **ONLINE**

CONTACT US

Keep in touch with the IR Science Interest Group.

IR SIG WEBSITE

https://cor.gsfc.nasa.gov/sigs/irsig.php

Our website is hosted on the NASA Cosmic Origins website.
It is a continual work in process; please contact us with any questions, comments, or suggestions for content.

@ir_sig

EMAIL LIST

https://cor.gsfc.nasa.gov/sigs/irsig/maillist/irsig_maillist.php

Sign up for announcements, information, and community discussion on our new email listserv! If you have been receiving email from us, no action is necessary, but if you have fallen out of touch or want to subscribe for the first time, please sign up.

IR SIG LEADERSHIP COUNCIL

The current members of the IR Science Interest Group (SIG) Leadership Council are:

Meredith MacGregor (Co-Chair)	University of Colorado Boulder
Mike Zemcov (Co-Chair)	Rochester Institute of Technology
Stacey Alberts	University of Arizona
Pete Barry	Argonne National Laboratory
Duncan Farrah	University of Hawaii
Jeyhan Kartaltepe	Rochester Institute of Technology
Jens Kauffmann	Massachusetts Institute of Technology
Lisa Locke	NASA Jet Propulsion Laboratory
Eric Murphy	National Radio Astronomy Observatory
Omid Noroozian	NASA Goddard Space Flight Center
Naseem Rangwala	NASA Ames Research Center
JD Smith	University of Toledo
Johannes Staguhn	Johns Hopkins University, NASA GSFC
Kevin Stevenson	Applied Physics Laboratory

Additional information about the IR SIG or to contact the IR SIG LC directly,

email: irsiglc@gmail.com.