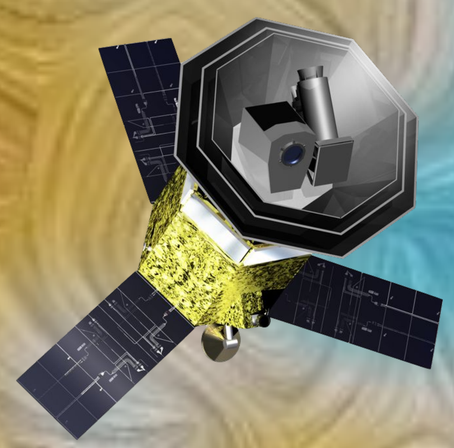


SWEDEN

National interest

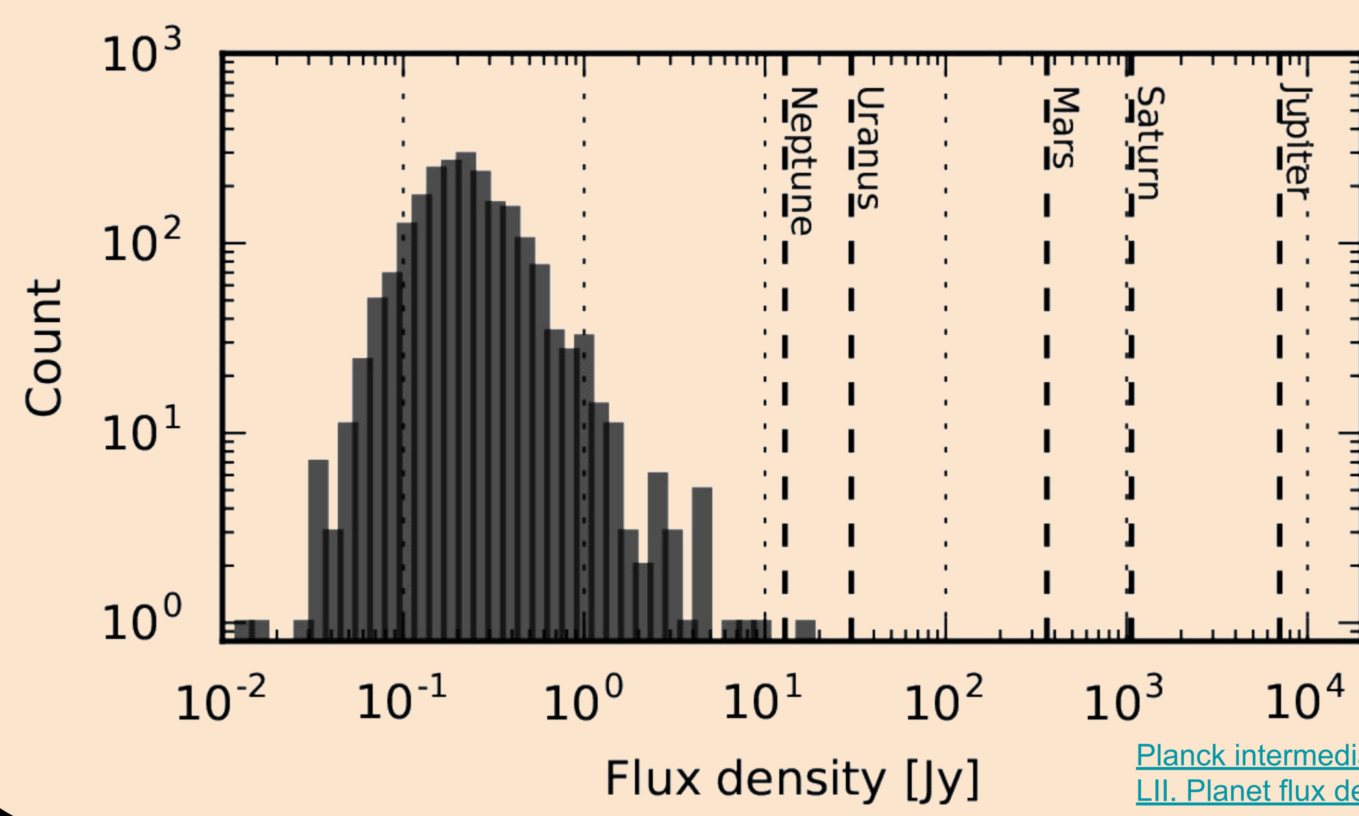
Sweden has not been a particularly active contributor to efforts in cosmic microwave background (CMB) observations. However, this is gradually changing as people with experience in the field are being recruited. This year, we will graduate our first PhD student working on CMB theory and data analysis; and this fall, two new PhD students will join our group. A number of theoretical physicists are working in areas related to the CMB. They include: Axel Brandenburg, David Marsh, Katherine Freese (50%), Leonid Kuzmin, Garrelt Mellema, Edvard Mörtsell, Hiranya Peiris (50%), and Martin Sahlen. Contributions to the LiteBIRD effort have been funded by Stockholm University, the Oskar Klein Centre for Cosmoparticle Physics, and the Swedish National Space Agency.

- Sweden is leading The LiteBIRD MHFT optics design and systematic mitigation effort. We expect to also work on low level and mid-level data analysis, including absolute calibration, beam reconstruction, and systematic characterization
- Sweden is proposing to contribute the design and construction of a cryostat for MHFT calibration efforts

Rymdstyrelsen
Swedish National Space Agency

Beam reconstruction

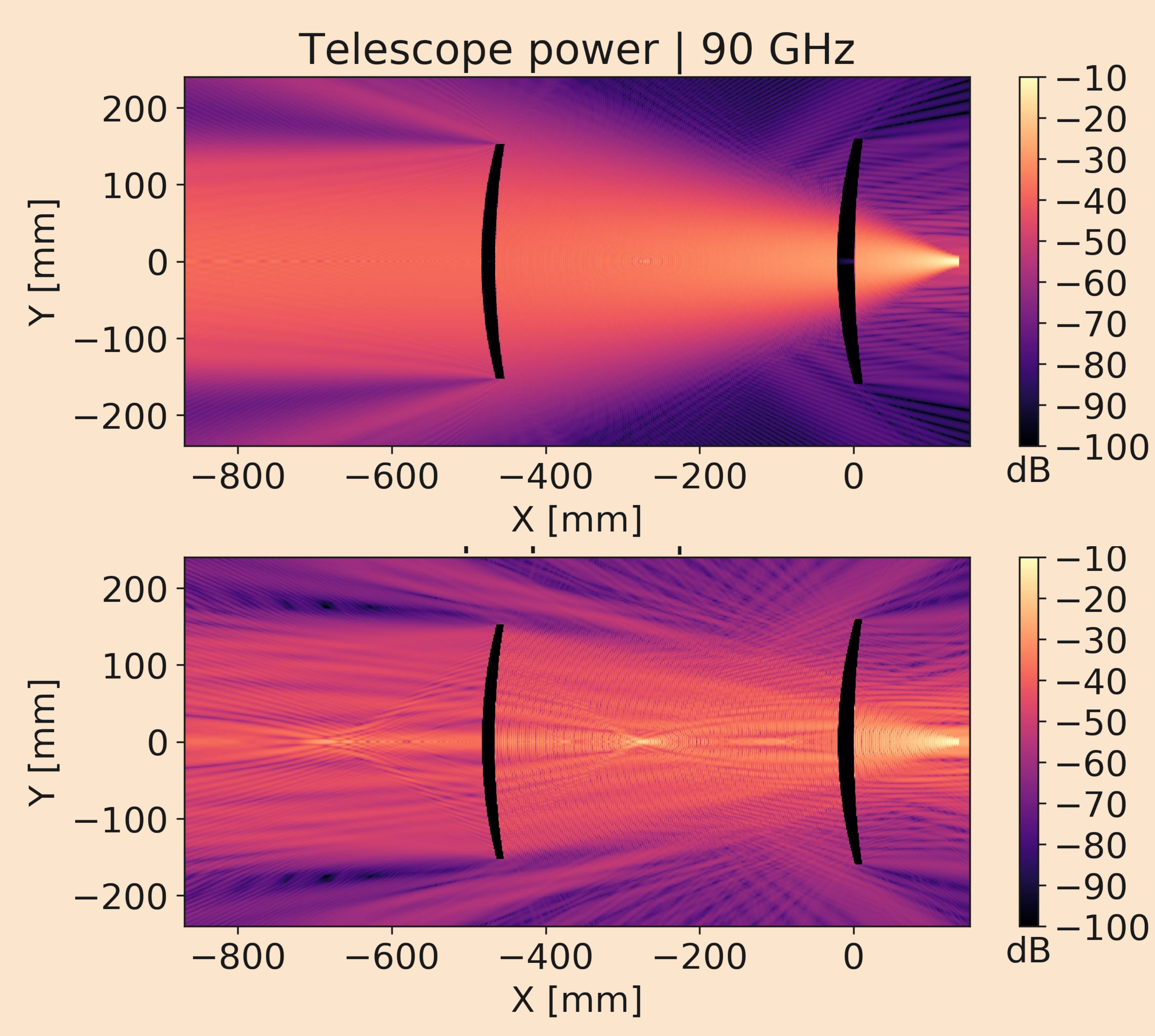
Researchers in Sweden contributed to the beam reconstruction pipeline for the Planck High Frequency Instrument. This included developing a time-domain simulation pipeline that incorporated the impact of various instrumental effects on both the statistical and systematic error in scanning beam reconstruction. This pipeline was run with both a Gauss-Hermite and a b-spline decomposition method. This work also informed planet flux estimates for the five outer planets, Mars, Jupiter, Saturn, Uranus, and Neptune. The figure below shows a histogram of 217-GHz point sources from the Planck Compact Source catalog and compares them to the flux from the five planets. The planets are by far the brightest sources in the mm-wavelength sky. The LiteBIRD satellite will use similar techniques to characterize its far field beam response. In particular, we expect that spurious observations of Jupiter will be crucial for understanding the LiteBIRD beam response.



[Planck intermediate results. LII. Planet flux densities (2017)]

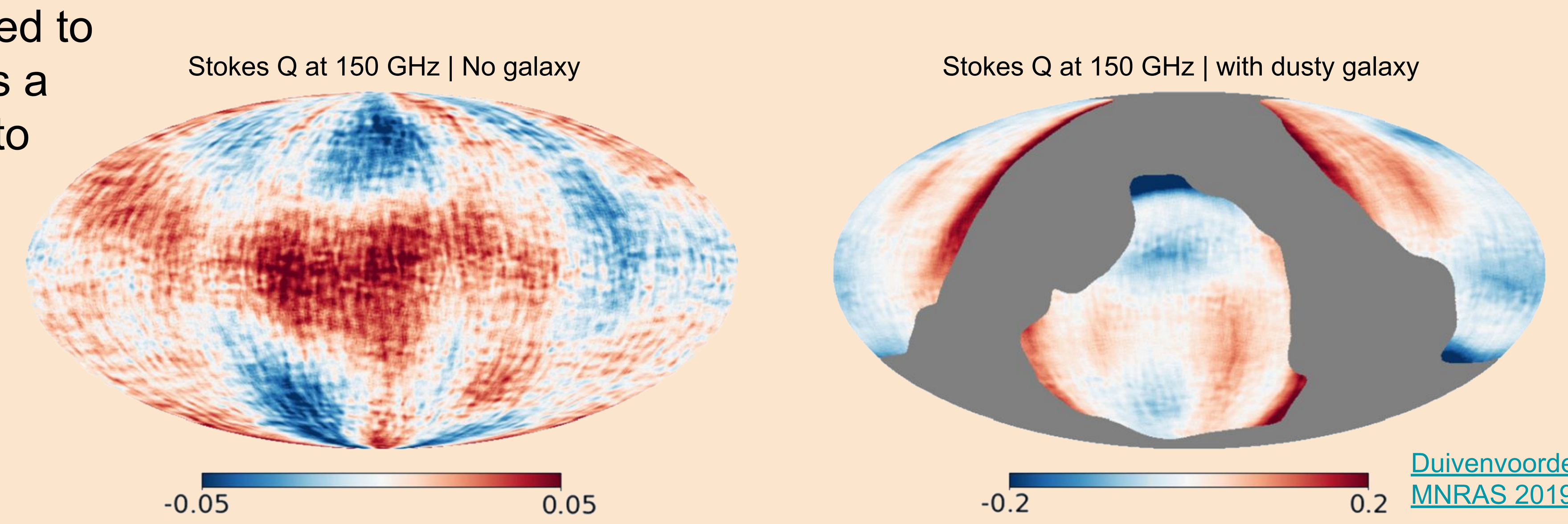
Optical modeling

Researchers in Sweden have contributed to optical modeling for CCAT, Simons Observatory, SPIDER, and the LiteBIRD satellite. These simulations incorporate an API that interfaces with a GRASP—a state-of-the-art commercial software—to perform both physical optics and full wave solutions (method of moments). These types of optical simulations help us understand how lens material properties and non-idealities degrade the far field response of our telescopes. The figure on the right shows the power distribution in a two-lens silicon refractor that is being illuminated by a Gaussian pixel beam at the focal plane. The top panel shows the power distribution (at 90 GHz) for a case when the lenses are anti-reflection (AR) coated with a three-layer metamaterial while the bottom panel show the case that has no AR coating. Similar studies will be performed for the different AR coating solutions proposed for the LiteBIRD optics. Given the wide frequency of the MFT (100-200 GHz) and HFT (200-400 GHz) optics, we expect that internal reflections and AR coating requirements will be given particular attention. Stockholm University uses a dedicated optical analysis machine with 36 physical cores and 512 GB of ram.



Beam convolution

Without proper care, optical systematics can limit searches for primordial B-modes by mimicking the cosmological signal. In order to fully understand how different optical systematics impact our science goals, we need to run realistic time-domain simulations that incorporate high fidelity beam models and proposed observation strategies. Researchers at Stockholm University have developed a full-sky harmonic domain beam convolver called *beamconv*. The code (https://github.com/AdriJD/beamconv) is lightweight, open source, and written completely in Python. In a recent publication we used *beamconv* to explore the impact of various optical non-idealities on the science goals of a fiducial satellite designed to study the polarization of the CMB on degree scales. Among other things, that analysis demonstrated how far sidelobes can convert unpolarized signal from the Galaxy into a polarized signal that is perceived to originate in regions of high Galactic latitude that are supposed to have low Galactic contamination. Suppression of far sidelobe response is a critical aspect of the LiteBIRD optical design effort. An near-term update to the *beamconv* simulation includes simulations of various half-wave plate (HWP) non-idealities, including frequency dependent phase shifts and differential transmission.



[Duivenvoorden et al. MNRAS 2019]

SC National member: Jon E. Gudmundsson
jon@fysik.su.se