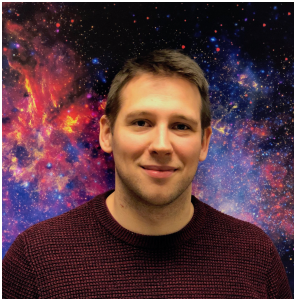


Kasper Heintz



Title

Measuring the HI gas mass of galaxies in the early universe with cosmic explosions

Abstract

The first epoch of galaxy formation is governed by the infall of neutral, pristine gas. These neutral atomic hydrogen (HI) gas reservoirs will subsequently cool and condense into molecular clouds and initiate star-formation. The HI gas content is therefore a key ingredient in the overall process of galaxy evolution. In the local Universe the hyperfine HI 21-cm transition has been used as the main tracer of this neutral atomic gas, but due to the weakness of the line this approach is only feasible at moderate lookback distances for individual galaxies, even with next generation radio observatories. In this talk I will present a new approach to infer the HI gas mass of high-redshift galaxies, based on an empirical measurement of the [CII]-to-HI conversion factor using gamma-ray bursts. These bright cosmic beacons are used to illuminate the column density ratio of HI and [CII], which provides a scaling between the HI mass and [CII] luminosity per unit column in the line of sight. I will demonstrate how this conversion factor can be applied to recent galaxy samples surveying [CII] out to the edge of the epoch of reionization, at $z \sim 6$. The HI gas mass is found to exceed the stellar mass at redshifts greater than $z \sim 1$, and to increase as a function of redshift. Similarly, the fraction of HI to the total baryonic mass of these galaxies is observed to increase from around 25% at $z=0$ to about 60% at $z \sim 6$. Further, I will show how the association of [CII] with HI also naturally explains the observed, more extended [CII] emission maps of high-redshift galaxies. I will also demonstrate how this technique makes it possible to infer the cosmic HI gas mass density in galaxies from $z \sim 6$ to the present, based on estimates of the [CII] luminosity density. These results show the baryonic matter of star-forming galaxies in the early Universe is dominated by neutral atomic gas, a vital component to take into account when determining the gas available to initiate and maintain star formation.

Curriculum Vitae for Kasper Elm Heintz

- Personal info:** Full name: Kasper Elm Heintz
Date of birth: April 18, 1991
Nationality: Danish
- Family:** Wife: Julie Elm Heintz
Children: Oliver Elm Heintz (b. 2016) and Alfreð Elm Heintz (b. 2020)
Paternity leave: June - August 2016 and December 2020 - January 2021
- Contact info:** E-mail: keheintz@hi.is
Webpage: keheintz.github.io
Phone: + 45 2382 4056
- Position:** Rannís Postdoctoral fellow (2021 –),
Centre for Astrophysics and Cosmology,
Science Institute, University of Iceland

Instrument Scientist for the NOT Transient Explorer (NTE; n.te.nbi.ku.dk)
- Interests:** High-redshift galaxies, dust and molecules in the ISM, gamma-ray bursts, quasars, damped Lyman- α absorbers, kilonovae, fast radio bursts
- Education:** 2016 - 2019: PhD in astrophysics, University of Iceland, Iceland.
Thesis entitled: *Galaxies through cosmic time illuminated by gamma-ray bursts and quasars* (supervisor: Páll Jakobsson)
2014 - 2016: MA in astrophysics, University of Copenhagen, Denmark
2011 - 2014: BA in physics with specialization in astronomy, University of Copenhagen, Denmark
2007 - 2010: High-school, Gladsaxe Gymnasium, Denmark.
- Employment:** 2021 - : Rannís Postdoctoral fellow (individual grant), University of Iceland
2019 - 2021: Postdoctoral researcher, University of Iceland
- Publications:** My publication record includes 57 refereed publications (16 as first author) currently listed in the Astronomical Data System (ADS). These publications include 4 papers in *Nature* and have a total number of citations of more than 3600.
h-index (number of publications with more than h citations): 21
ORCID: 0000-0002-9389-7413
- Expertise:** *Observing:* I have so far observed 5 times with the Nordic Optical Telescope (NOT) and 1 time with the New Technology Telescope (NTT) at the ESO La Silla observatory. I have observed remotely several times, typically a few nights per month on duty for the various FRB, GRB or GW collaborations. This includes submitting triggers and observing with the NOT, VLT, Gemini, NTT, and the space-based *HST*.
Data analysis: I have experience with UV/optical imaging and spectroscopic data reduction and analysis, in addition to ALMA observing preparation and data analysis. I am also co-developer of a spectroscopic reduction package (public available here: github.com/keheintz/PyReduc).
Webpages: I have created and am currently running the webpage <http://frbhosts.org>, providing an up-to-date compilation of all known FRB host galaxies and their basic properties. I have also contributed to <https://github.com/FRBs/FRB> and <https://frb.software>.

Collaborations: I am an active member of these collaborations:

- Fast and Fortunate for FRB Follow-up (F⁴)
- The Commensal Real-time ASKAP Fast Transients Survey (CRAFT)
- Real-time, Commensal Fast Transient Surveys with the Very Large Array (*realfast*)
- Hunting for the most exotic gamma-ray bursts with the VLT (STARGATE)
- Electromagnetic counterparts of gravitational wave sources at the Very Large Telescope (ENGRAVE)
- The extended Public ESO Spectroscopic Survey for Transient Objects (ePESSTO)
- 4MOST-*Gaia* Purely Astrometric Quasar Survey (4G-PAQS)

For the F⁴ and CRAFT collaborations I am leading the optical follow-up of FRB host galaxies at the VLT. For the STARGATE and ENGRAVE consortia I am mainly working as part of the "burst alert team", being on call typically 1 week every other months to observe GRB- and GW-detected optical afterglows with the NOT and the VLT. For the 4G-PAQS collaboration I am the survey representative on the Science Policy board, and in charge of the survey design and target selection.

Leadership:

I have been principal investigator on a large number of observing programs at the ESO-VLT, NOT, and ALMA, and co-investigator on other active programmes for the JWST, HST, Gemini, and more. I am currently the PI of a Large Programme awarded 180 hr of observing time at the ESO-VLT to build the first homogeneous and unbiased FRB host galaxy sample. I am supervising two Masters students for their thesis project and have previously supervised one Bachelor student and co-supervised 3 first-year projects. I also work as the Instrument Scientist for the NOT Transient Explorer, with the key task to ensure that the capabilities of this instrument meet the science requirements.

Teaching:

I have taught the following courses:

- 2021: Observational Astrophysics, Co-lecturer, University of Copenhagen
- 2021: Extragalactic Astrophysics, Teaching Assistant, University of Copenhagen
- 2021: Astronomical Observations, Data Reduction and Analysis, Co-lecturer (1 of 4), University of Iceland
- 2020: Literature study for the Master's degree in physics, Lecturer, University of Iceland
- 2018-2019: Introduction to physics, Teaching Assistant, University of Iceland
- 2018: Spacetime physics, Teaching Assistant, University of Iceland
- 2015: Observational astrophysics, Teaching Assistant, University of Copenhagen

Services:

I was chair for a special session at the EAS 2021, on "*Gamma-ray bursts as cosmic probes: The next 10 years*".

I have served as referee for the *Astrophysical Journal*, *Astronomy and Astrophysics*, *Monthly Notices of the Royal Astronomical Society* and the *Canadian Time Allocation Committee (CanTAC)*.

I enjoy and make an effort to speak to the general public as often as possible, typically 5 – 10 times a year.