



MIT KAVLI INSTITUTE

HETG/LETG — Status

Chandra Quarterly Review No. 53

26 May 2022

Norbert S. Schulz

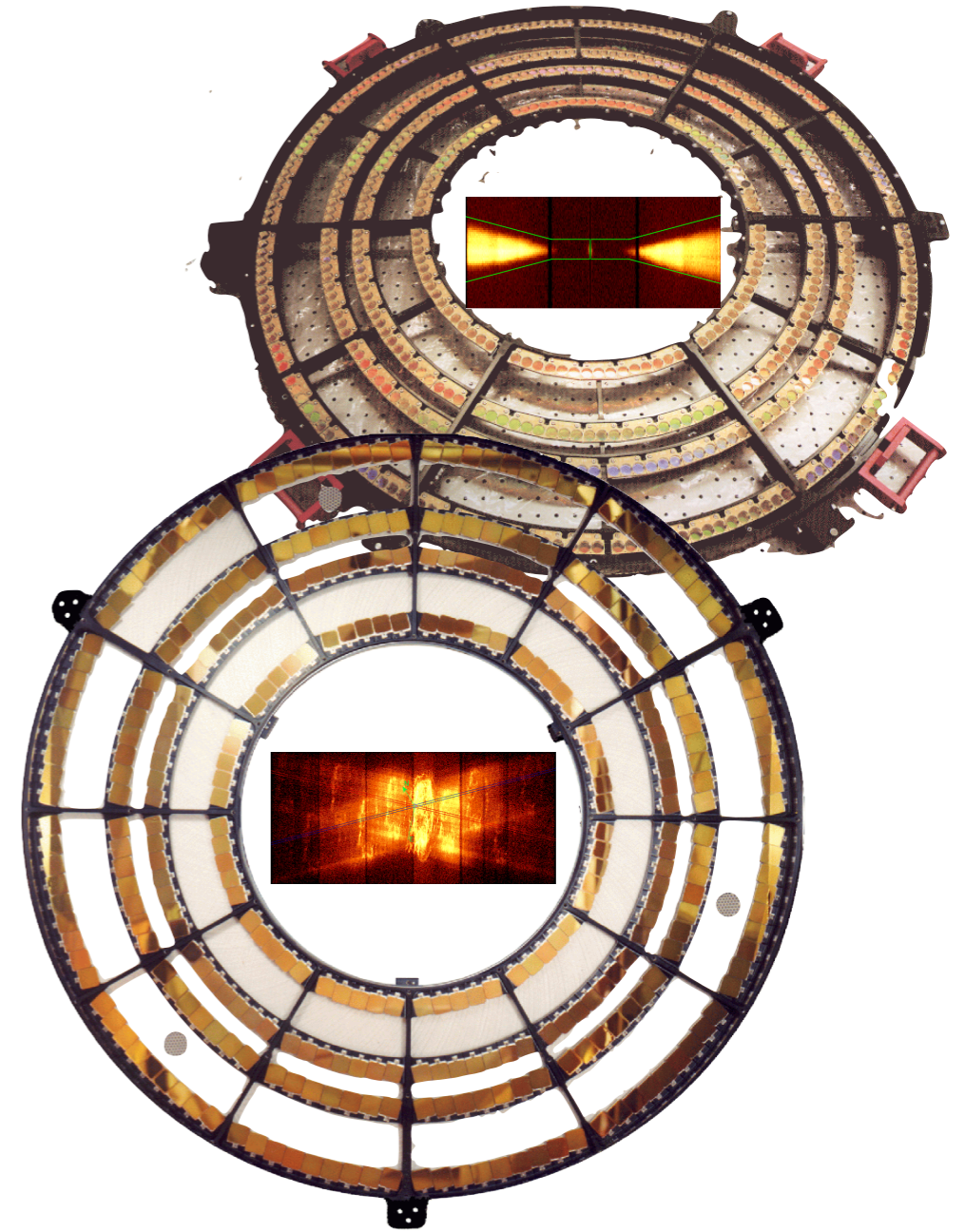
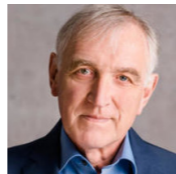
nss@space.mit.edu

(<https://space.mit.edu/HETG>)

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MIT Kavli Institute

LETG IPIs: Dr. Peter Predehl
Max Planck Institute

Dr. Jelle Kaastra
SRON



HETG GTO Science Program



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Proposal Cycle 22:

- ★ Stars: ρ Oph A 111/200 ks Winds of OB stars; magnetic confinement
- ★ AGN: Mrk 335 82 ks Jets, disks, outflows, variability (w/NuSTAR, NICER).
- ★ AGN: NGC 1365 295 ks Seyfert 1.8 galaxy; outflow, variability.
- ★ BH: SS 433 210 ks Stellar mass black hole; relativistic jets, variability
- ★ NS: Terzan 5 X-2 0/200 ks Neutron Star outburst (TOO)
- ★ NS: Cen X-4 0/60 ks Neutron Star outburst (TOO)
- ★ NS: 4U 1820-30 175 ks Neutron Star outburst; gravitational redshift, NS radius (TOO)
- ★ ISM: GX 3+1 0/100 ks Silicon K-edge structure and variability
- ★ ISM: GX 17+2 66/100 ks Silicon gas-to-dust ratio (part of ISM survey)
- ★ XRB: 4U 1626-67 58 ks Ultra-compact binary; monitor disk line shapes

Proposal Cycle 23:

- ★ Stars: π Aqr 0/100 ks Winds of the hottest stars
- ★ AGN: Circinus Galaxy 0/70 ks Emission lines, morphology, variability (IXPE-coordinated)
- ★ XRB: Cen X-3 0/62 ks Eclipsing X-ray pulsar; accretion
- ★ XRB: 4U 1629-67 89.9/90 ks Ultra-compact binary; monitor Fe lines.
- ★ XRB: GX 1+4 0/90 ks Low-mass XRB; accretion, Compton shoulder study.
- ★ ISM: GX 340+0 28/150 ks Cosmic dust composition
- ★ ULX/NS: M33 X-8 28/92 ks Pulsar wind outflow, absorption
- ★ ULX: LMC/SMC X-? 0/70 ks Accretion disk outbursts (TOO)
- ★ NS: Terzan 5 X-2 0/200 ks Neutron Star outburst (TOO)

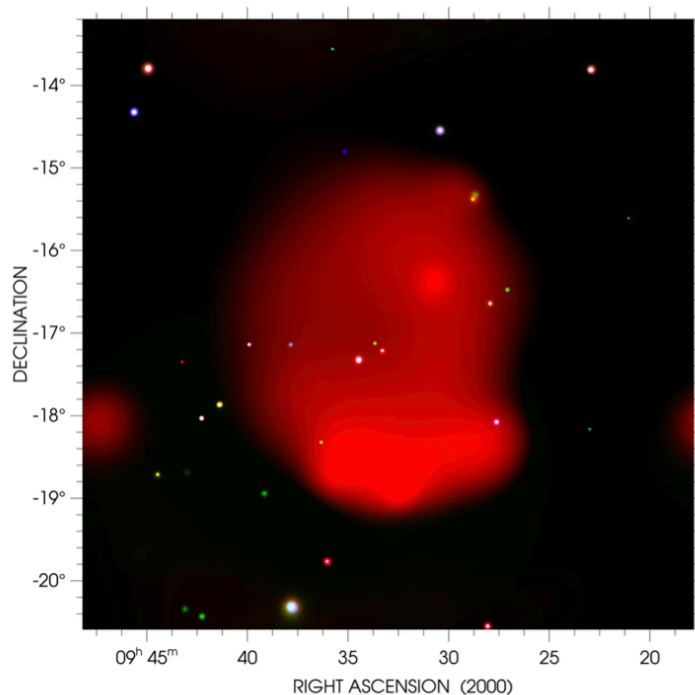
AGN: Active Galactic Nucleus
BH: Black Hole
ISM: InterStellar Medium
NS: Neutron Star
SN: SuperNova
ULX: Ultra-Luminous X-ray source
SNR: SuperNova Remnant
XRB: X-ray Binary
LMXB: Low Mass XRB

LETG GTO Science Program



- Proposal Cycle 22:**
- ★ Stars (Predehl/MPE) RX J0859.1+0537 60 ks Accretion onto white dwarfs (LETG/HRC-S)
 - ★ Stars (Predehl/MPE) RX J1002.2-1925 0/48 ks Accretion onto white dwarfs (LETG/HRC-S)
 - ★ AGN (Predehl/MPE) HSC J092120.56+000722.9 21 ks Confirmation of faint $z=6.56$ eROSITA Quasar (ACIS-S)
 - ★ AGN (Predehl/MPE) 2MASX J09325962+0405062 50 ks Confirmation of eROSITA Compton-thick Seyfert (ACIS-S)
 - ★ AGN (Kaastra/SRON) MR 2251-178 62/175 ks Galaxy outflows, absorption line density diagnostics (LETG/HRC-S)

- Proposal Cycle 23:**
- ★ Stars (Predehl/MPE) LTT 1445A 0/50 ks High energy environments of terrestrial exoplanets
 - ★ Stars (Predehl/MPE) L 168-9 0/25 ks High energy environments of terrestrial exoplanets
 - ★ SNR (Predehl/MPE) Hoinga 0/60 ks Distance determination
 - ★ AGN (Predehl/MPE) WISEA J202040.85-621509.3 0/30 ks Confirm eRosita detection of a $z=5.9$ quasar
 - ★ Galaxies (Kaastra/SRON) Abell 141 0/175 ks Intercluster temperatures, merger history



Hoinga: eRosita image; largest supernova remnant discovered in X-rays.

Size of HRC-I

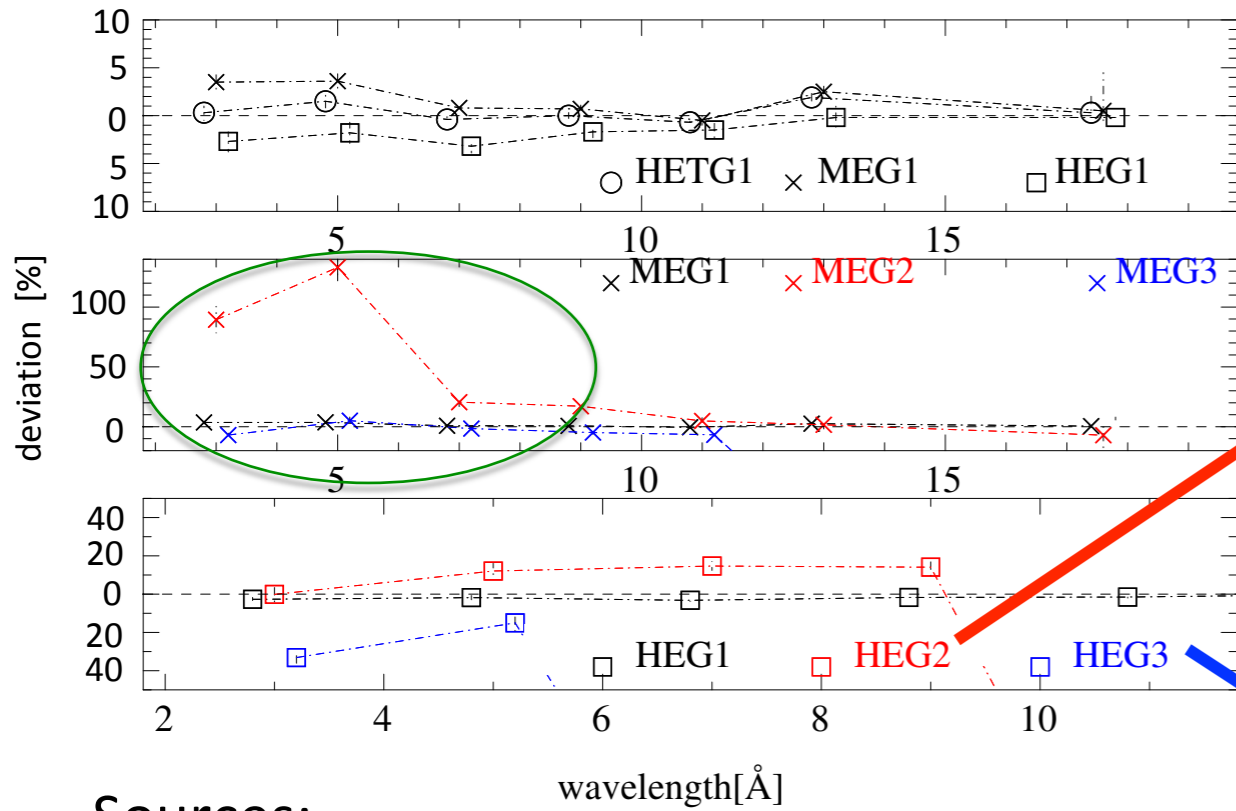
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 LMXB: Low Mass XRB

HETG Higher Order Calibration (*in progress*)



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PKS 2155-304

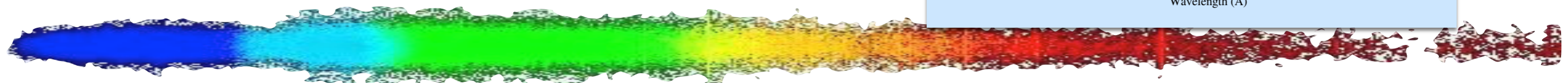
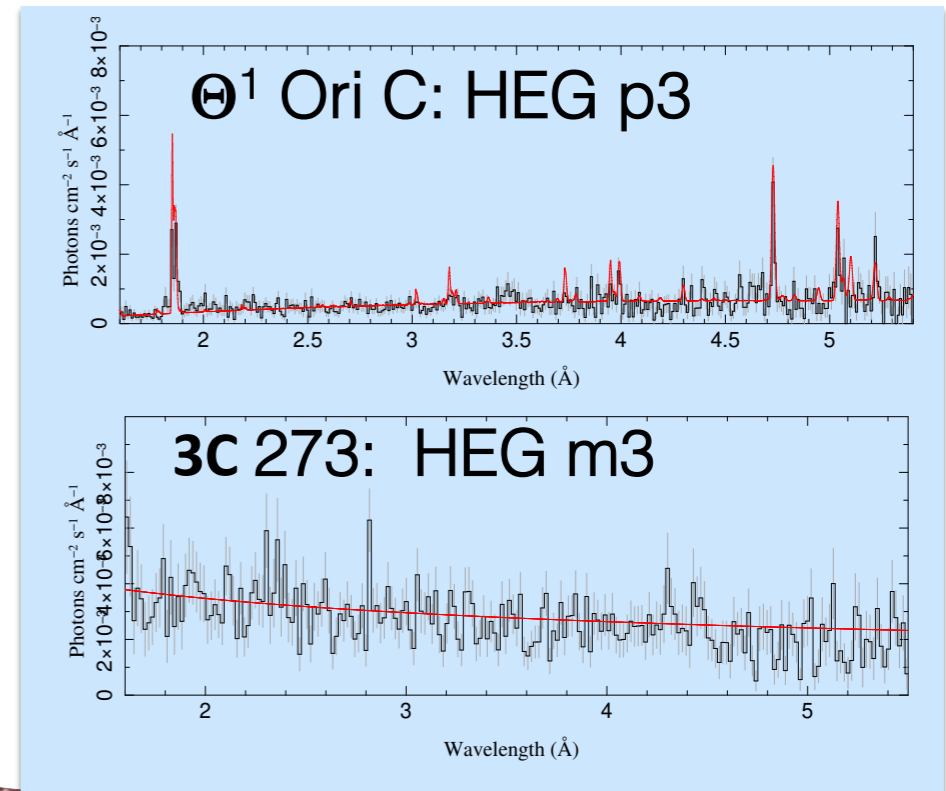
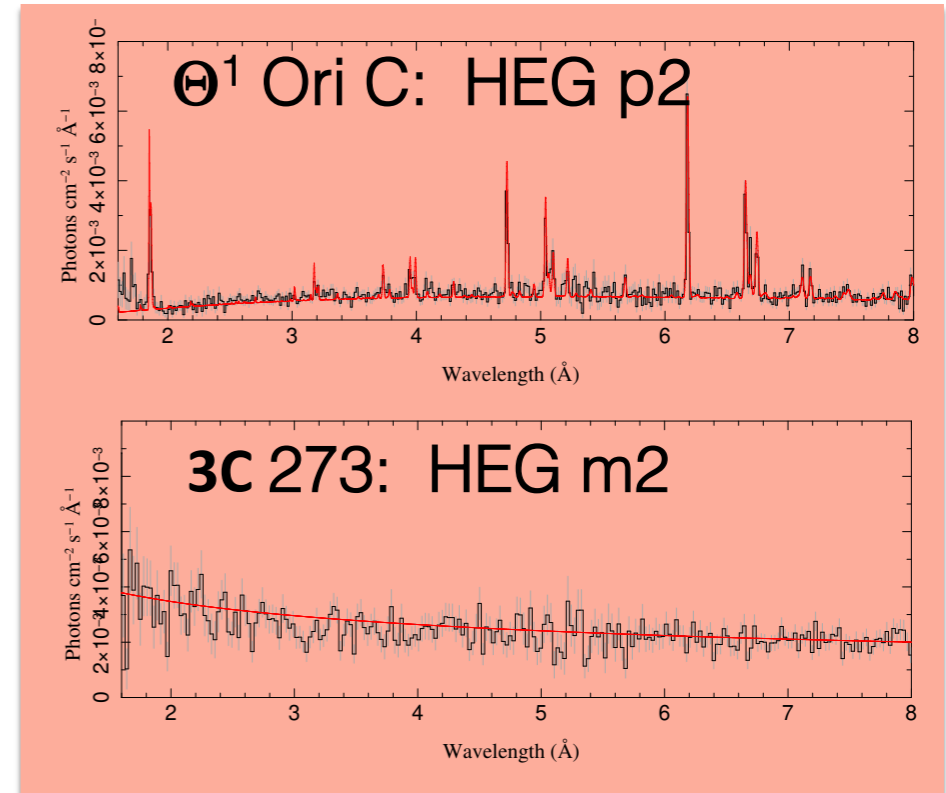


Sources:

Θ^1 Ori C : 2.27 Ms PKS 2155-304: 0.29 Ms

3C 273: 0.54 Ms 4U 1626-67: 0.38 Ms

NGC 4151: 0.68 Ms NGC 3783: 1.13 Ms

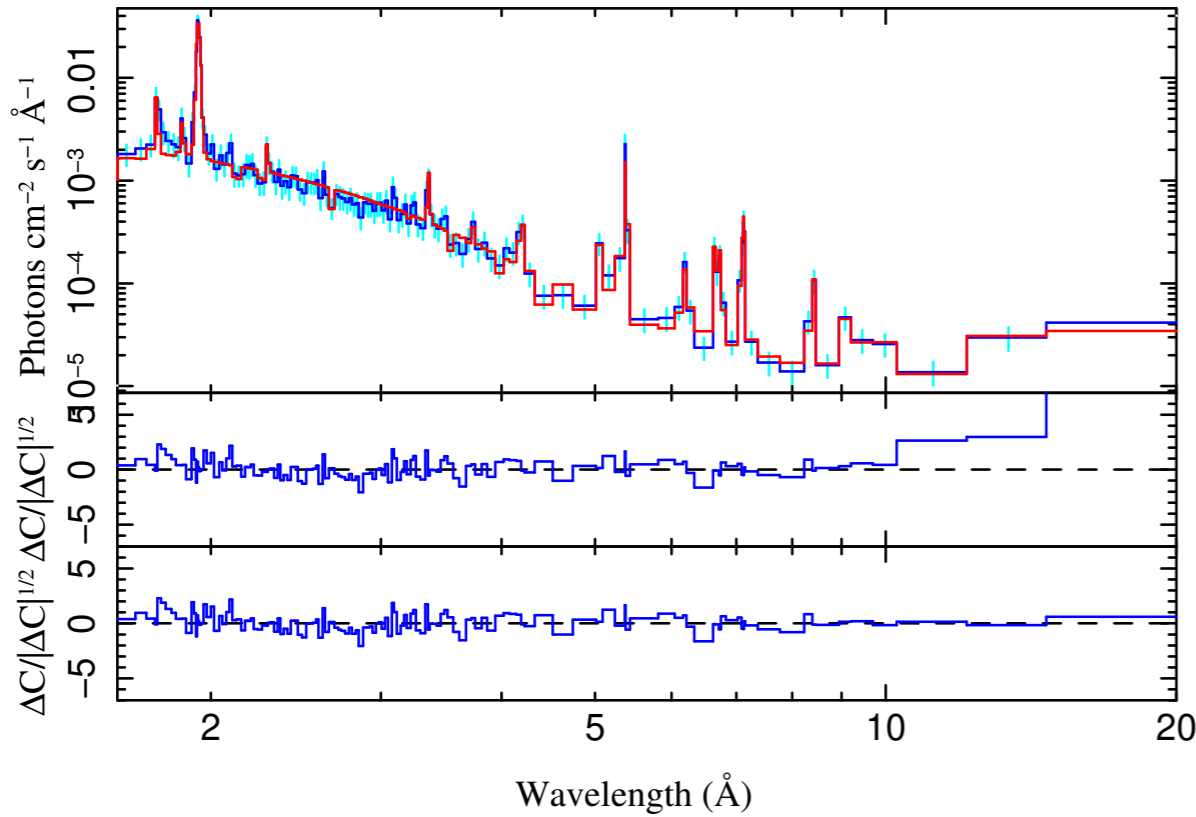




Science Highlights (published in the past 12 months) - 1

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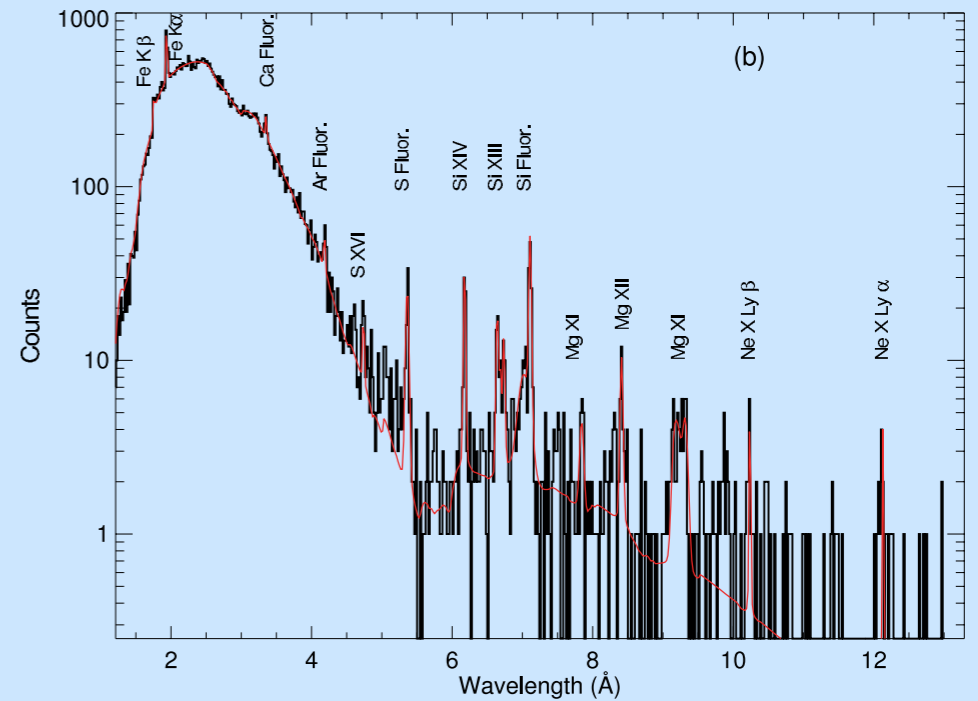
Probing clumped winds with neutron stars in HMXBs:



Martinez-Chicharro et al. 2021, ApJ, 592, 516
4U 1700-37 in eclipse

Strong fluorescence lines Fe, Ca, Ar, S, Si
Strong ionized lines: S, Si, Mg (no Fe, Ca, Ar)

Boroson et al. 2003, ApJ, 592, 516
4U 1700-37 out of eclipse



High/Low flux phase during eclipse in 4U 1700-37:

Strong fluorescence lines Fe, Ca, Ar, S, Si

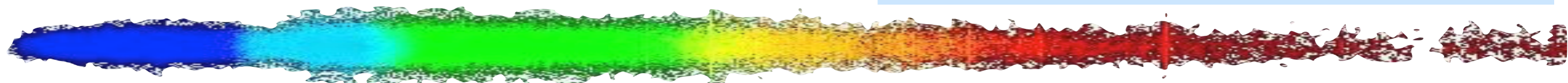


Located throughout bulk of wind

Weak ionized lines: S, Si, Mg (no Fe, Ca, Ar)



Originate close to neutron star



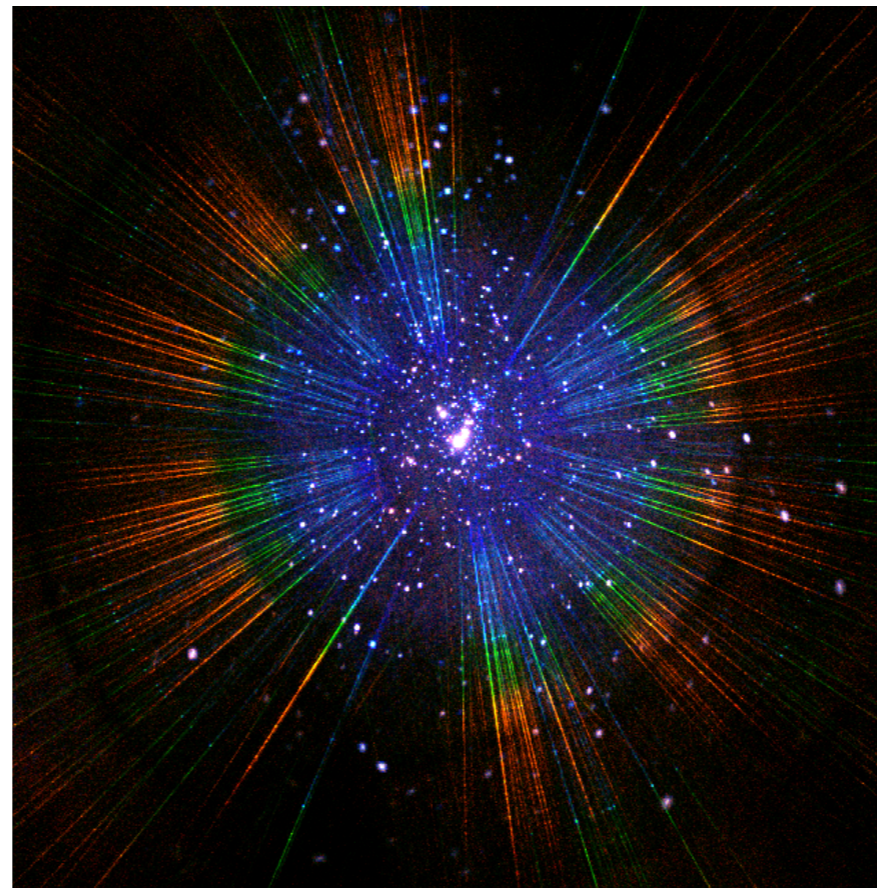
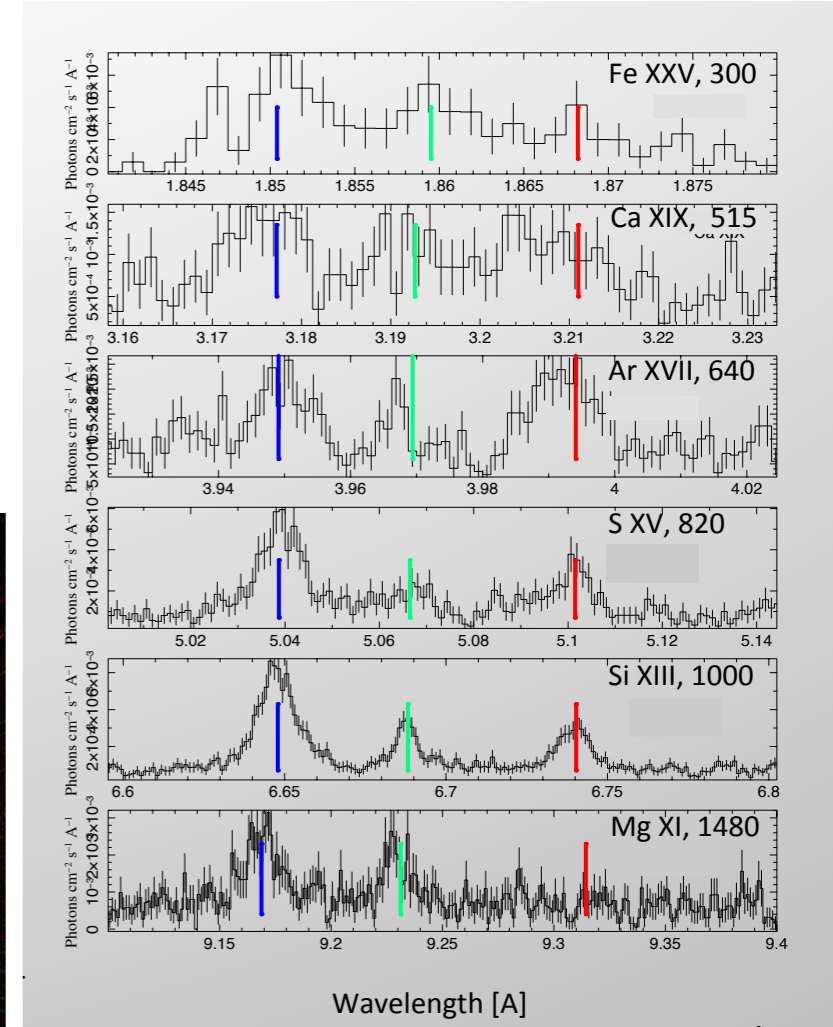
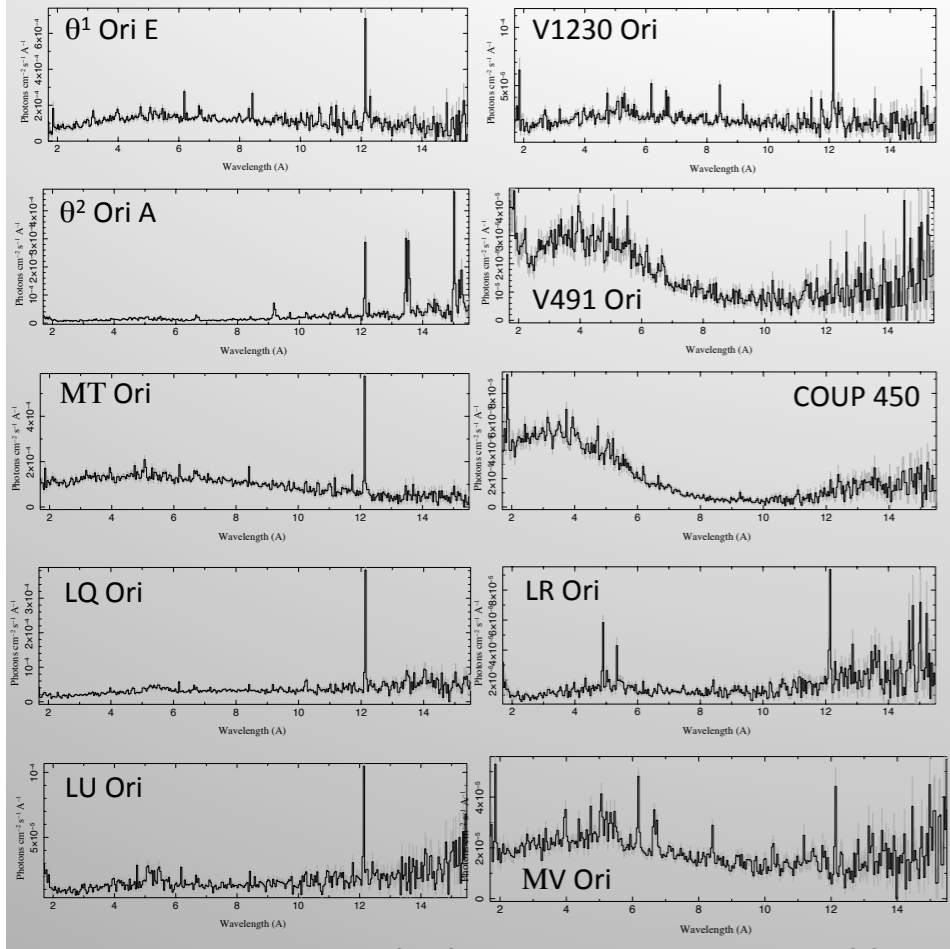


Science Highlights (HETG GTO/GO, Cycles 1-6, 21,22 *in progress*)

The Nature of X-rays in the Orion Nebula Cluster: A HETG Legacy project

Early Cycles: 585 ks (90% GTO)
Cycles 21/22: 1.65 Ms (100% GO)

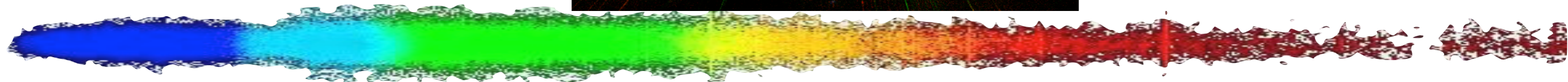
April 26 2022:
First Release of confusion cleaned
1st order HETG spectra



The release features 36 HETG spectra:

- 4 massive stars (likely all ~ZAMS)
- 8 intermediate PMS mass stars
- 24 low-mass PMS stars

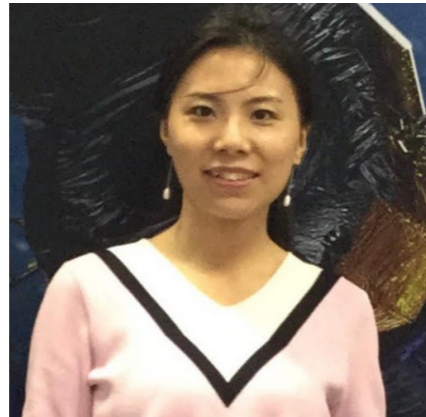
The co-added HEG 2nd and MEG 3rd orders of six He-like triplets: Mg XI, Si XIII, S XV, Ar XVII, Ca XIX and Fe XXV for 2.2 Ms of data from Θ^1 Ori C





Science Highlights (HETG GTO, Cycle 21-23, *in progress*)

Jun Yang
(MIT Postdoc)



Si K edge structure of LMXBs towards the Galactic Bulge

9 Highly absorbed Low Mass X-ray Binaries

($N_H \sim 4 \times 10^{21} - 9 \times 10^{22} \text{ cm}^{-2}$)

Gas edge @ 1.839 keV

-> probes neutral atomic gas

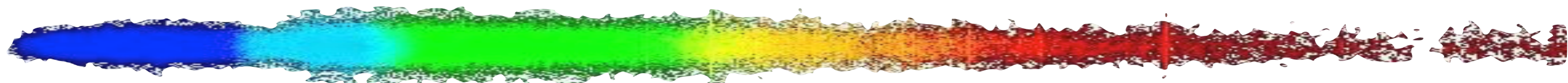
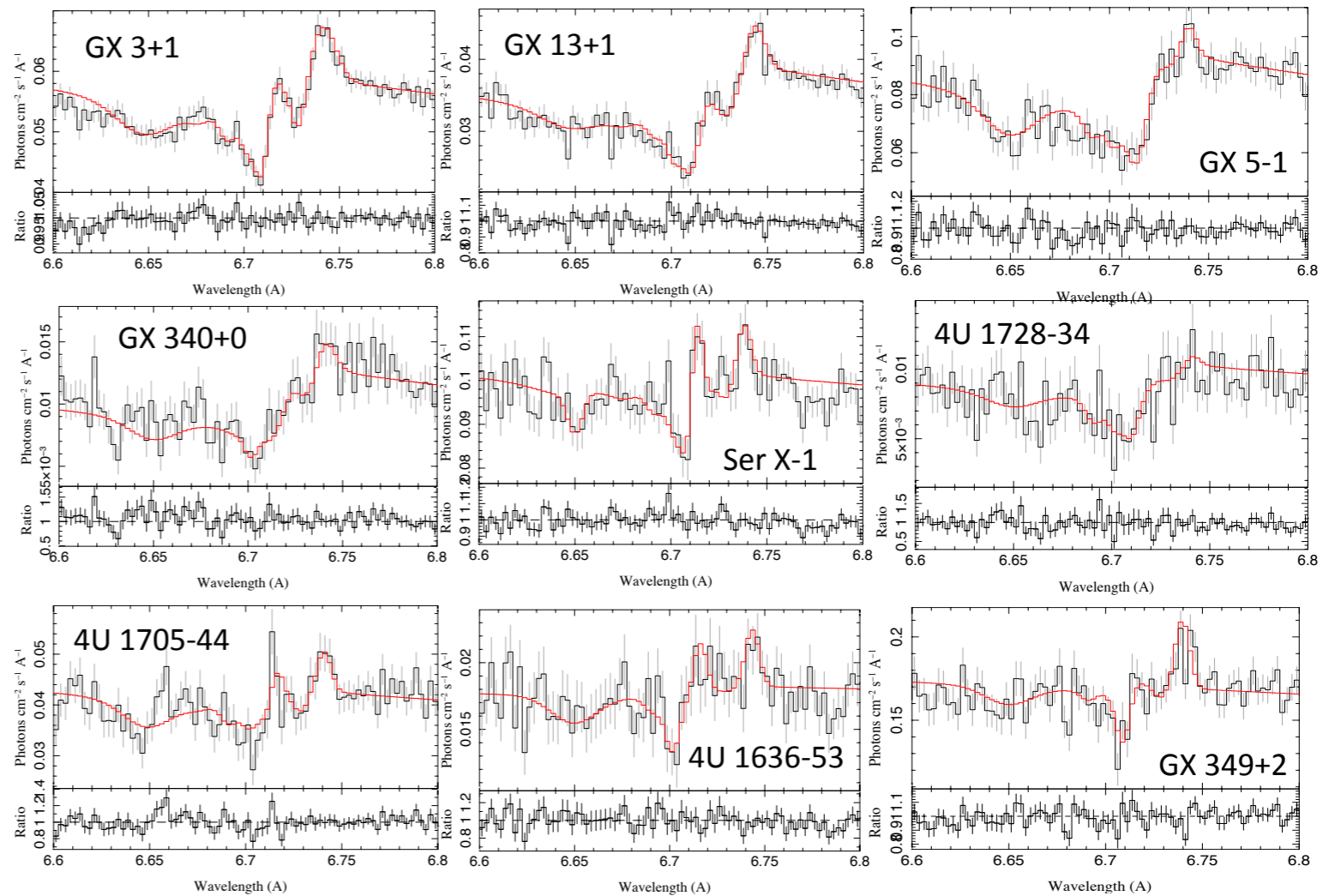
Dust edge at 1.844 keV

-> probes neutral dust

Ionized Si

-> weak Si II, III, Si XII, Si XIII

Possible HETG calibration probe involving the SiO_2 gate structure of front-illuminated CCDs.





end