Star Formation and Evolution SWG 3.2

Co-chairs:

Ann Hornschemeier (NASA GSFC)

Gregor Rauw (Institut d'Astrophysique et de Géophysique, Belgium)

Salvo Sciortino (INAF/Osservatorio Astronomico di Palermo)

Scope of this panel (according to email from Paul Nandra, March 6, 2015)

- Scope of panel: star formation, wherever it occurs in the Universe (in our Galaxy, external galaxies, and also at higher z).
- Paul Nandra : "A consequence of this of course is that the remit of panel 3.2 is rather broad, as will be the diversity of its membership. The chairs were also chosen to reflect this diversity. …. I can only see it as beneficial if those thinking about star-formation locally talk to and interact with those whose interests lie further afield."

X-ray emission from “normal” stars

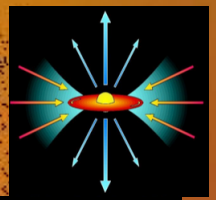
Wolf-Rayet stars

OB-stars

Winds,
magn.fields

A(p)-star

protostars
(Class 0; Class I)



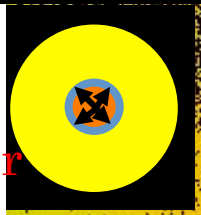
Pre-main sequence stars
(= T Tauri stars)

Accretion,
Jets, coronae

Solar-type stars

Coronae,

(&& targets for
exoplanetary
X-ray studies)



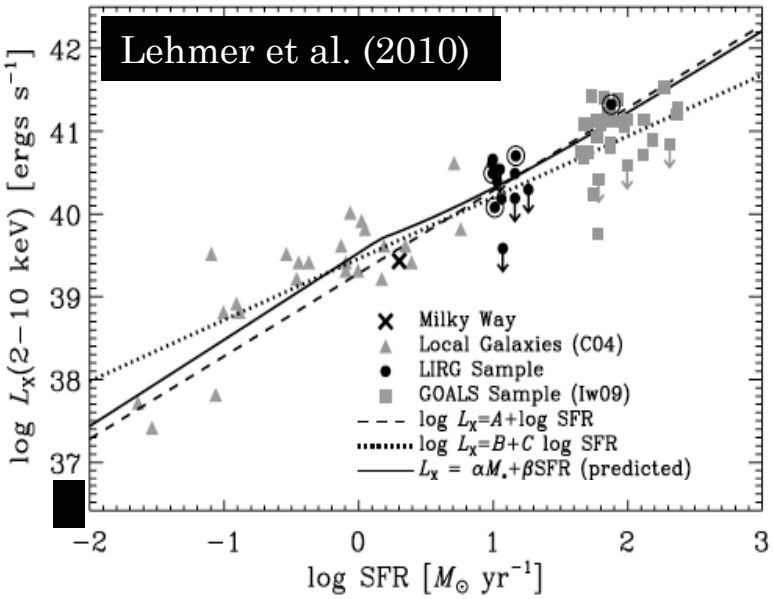
Very low-mass stars
+brown dwarfs

Coronae?

R-SCIOBJ-322 (mainly X-IFU)	Athena shall map the hot gas distribution in the wind interaction zone of binary systems where the winds from both components collide by phase-resolved spectroscopy	Wind interactions in binaries through phase-resolved spectroscopy of 13 massive binaries.
R-SCIOBJ-323 (X-IFU & WFI)	Athena shall measure magnetospheric accretion onto the photosphere and corona of young low-mass stars and brown dwarfs both in the field and selected star-forming regions by measuring time-series of high-resolution spectra to probe line-intensity variability from the accretion shock and post-shock plasmas, and the stellar corona.	Magnetospheric accretion in 18 young low-mass stars and brown dwarfs
R-SCIOBJ-324 (lowest bkg detector)	Athena shall measure magnetic activity in late M stars and ultra-cool dwarf stars by measuring their X-ray luminosity and temperature and their change during flares	Magnetic activity in 4 ultra-cool dwarf stars
R-SCIOBJ-325 (WFI)	Athena shall study the metallicity dependence of stellar wind mass-loss via the observation of X-ray emission from populations of massive stars in galaxies of the Local Group.	Measure X-ray spectra of selected OB associations (each with at least 10 massive stars) in 3 different Local Group galaxies with different metallicities.
R-SCIOBJ-332 (maily X-IFU) Joint with WG 3.3	Athena shall determine the geometry, porosity and mass loss-rate of stellar wind structure of isolated massive stars, especially in the presence of magnetic fields, through phase spectroscopy of time profile for a sample of objects. Time resolved spectral analysis of X-ray emission from a sample of high mass X-ray binaries hosting supergiant and hyper-giant companions shall be carried out to seek for independent estimates of massive star wind properties.	Characterise fully the mass-loss and winds of 30 single early-type stars, and of the mass donors in 7 HMXBs.

X-RAYS FROM GALAXIES OVER COSMIC TIME

LOCAL GALAXIES:



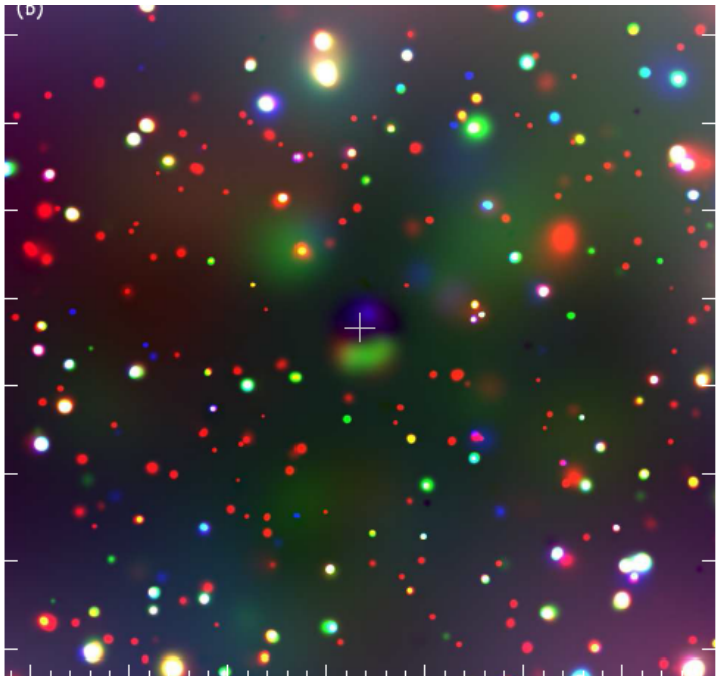
$L_X = L_X(\text{LMXBs}) + L_X(\text{HMXBs})$

$L_X = \alpha M_\star + \beta \text{SFR}$

$L_X/\text{SFR} = \alpha(\text{SFR}/M_\star)^{-1} + \beta$

DISTANT (HIGH-z) GALAXIES:

The Chandra Deep Field – South (6 Ms, 69+ days, Luo et al 2016)



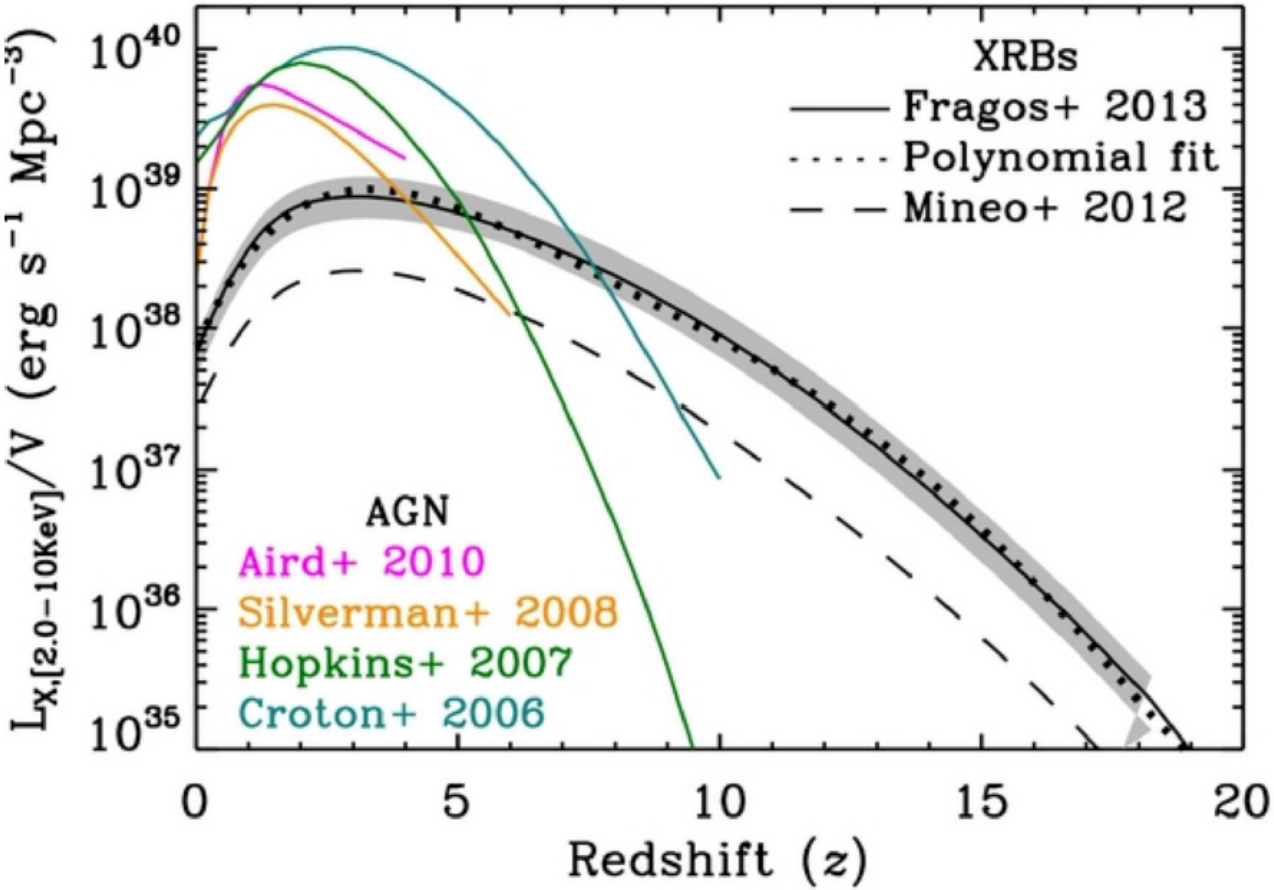
"True" color image

0.5-2.0 keV 2.0-4.0 keV 4.0-8.0 keV

$$L_X = \alpha_0(1+z)^3 M_\star + \beta_0(1+z)^{0.92}\text{SFR}$$

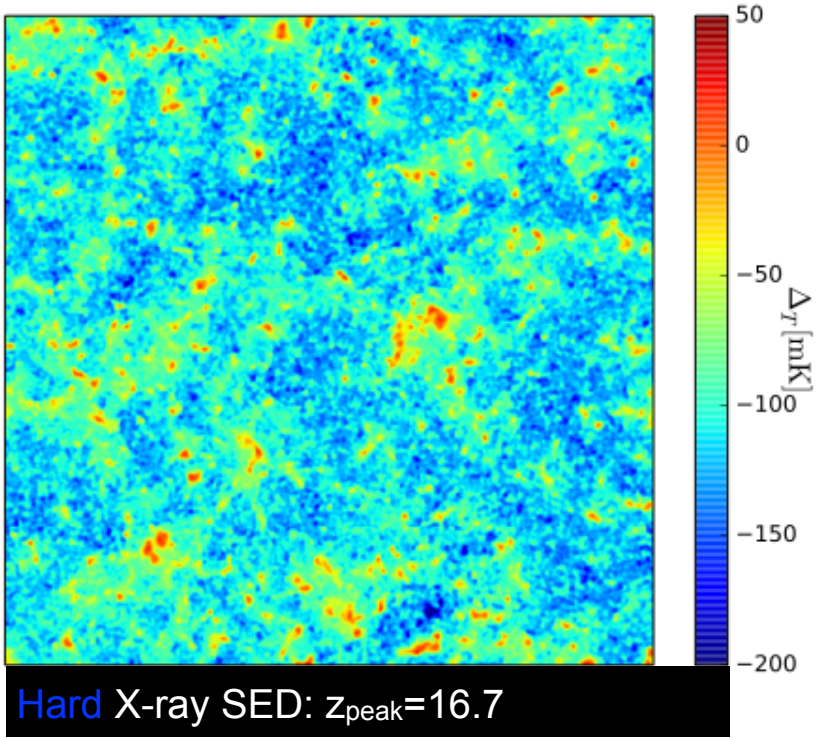
(B. Lehmer et al. 2015)

THE X-RAY OUTPUT OF BINARIES EXCEEDS THAT OF AGN AT Z>6



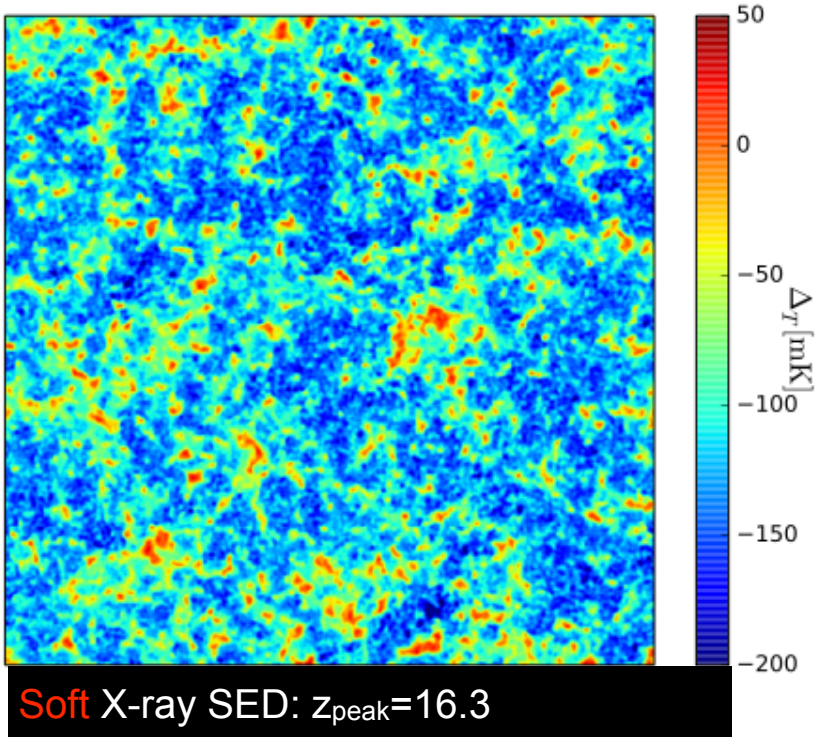
X-rays from star formation heat the early IGM (Pacucci et al. 2014): *Athena WFI will probe this emission directly*

Slices of the 21cm brightness temperature map taken at the X-ray heating peak at large scales (detectable by next-generation facilities like MWA, HERA and SKA):



Hard X-ray SED: z_{peak}=16.7

More uniform brightness temperature map, due to longer distance traveled by more energetic photons

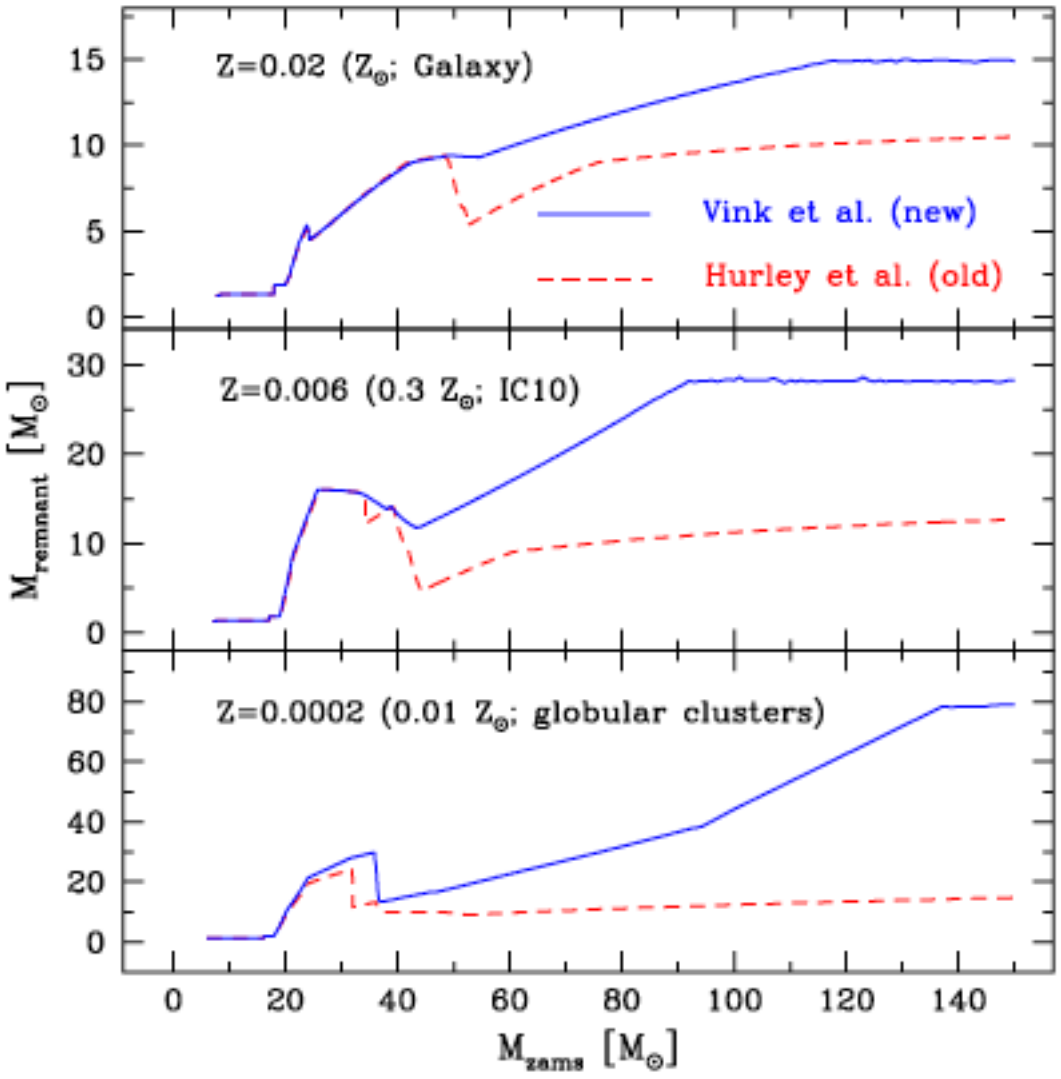


Soft X-ray SED: z_{peak}=16.3

Broader and more patchy distribution of *T*: there are large regions distant from galaxies still cooling adiabatically (not present in the hard SED model)

Outstanding issues: stellar wind prescriptions

BH/NS (remnant) mass predictions depend very much on details of stellar wind calculations (e.g., Belczynski et al. 2010)



ADDED A SCIENCE REQUIREMENT

- There was no level 1 requirement dealing with the metallicity dependence of the X-ray emission of stellar winds, in October 2015, we suggested adding R-SCIOBJ-325:

R-SCIOBJ-325 (WFI)	Athena shall study the metallicity dependence of stellar wind mass-loss via the observation of X-ray emission from populations of massive stars in galaxies of the Local Group.	Measure X-ray spectra of selected OB associations (each with at least 10 massive stars) in 3 different Local Group galaxies with different metallicities.

Example of Work by SWG 3.2, revising science requirements/mock Observing Plan

ISSUE WITH PROPERLY STUDYING STELLAR WIND MASS LOSS

- To identify trends in the X-ray properties of single massive stars (X-ray spectra as a function of spectral-type and luminosity class, including objects with and without magnetic fields, OB stars and WR stars), SWG 3.2 regarded the existing list of objects in the sample to be a strict minimum.
- However, since we are asked to restrict ourselves to 25 objects as written in document SWG3-Notes-191115, SWG 3.2 suggested removing 8 objects (HD110432, alpha Cam, mu Col, 15 Mon, HD162978, HD190429A, lambda Cep, BD+37° 1977).
- Remaining sample may not be sufficient to answer the questions raised.

Other SWG 3.2 activities

- Further refinement of wording of requirements, clarifying target lists…
- Characterizing stray light requirements for observing bright stars