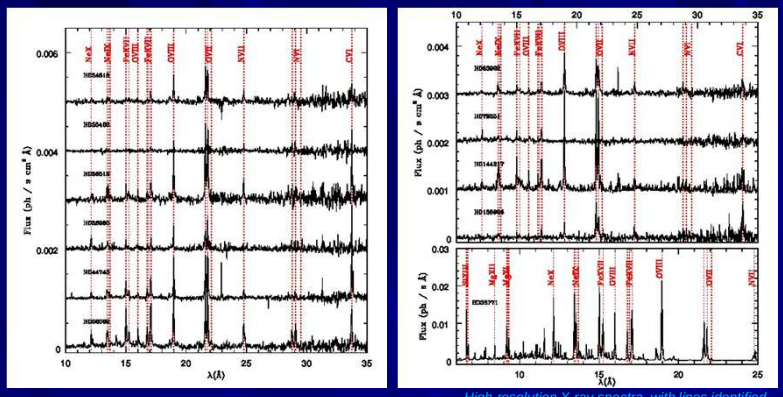
A legacy survey of early B-stars using the RGS

Introduction:

- While many O-stars have been the subject of studies at high-resolution, much less B-stars have been examined.
- There are 20 B-stars with RASS count rate > 0.1 cts/s hence easily studied at high spectral resolution
  - 8 were already analyzed and one is O+O binary
  - remaining 11: some archival exposures (XMM, Chandra) + our dedicated XMM-RGS legacy survey
- Standard reduction with SAS v 16 and CIAO 4.9, filtering for solar flares, discarding nearby companions (extraction in a smaller area in such cases), combining when several exposures



High-resolution X-ray spectra, with lines identified.

Results: *(Cazorla et al. 2017, A&A, in prep)*

1) Lines

- He triplets larger than Lyα, in line with late-type massive stars results
- Gaussian fittings:
  - No significant line shift
  - No significant line broadening, except for HD38771 where HETG data indicate FWHM~1250km/s
- Line ratios:
  - Temperatures = low, typically log(T)~6.35

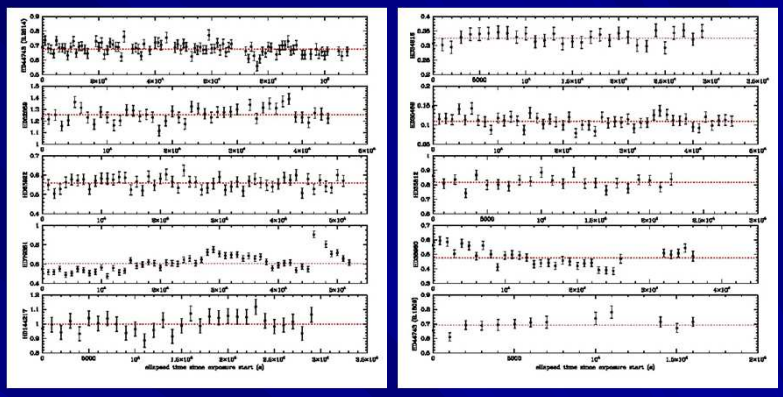
2) Global fits

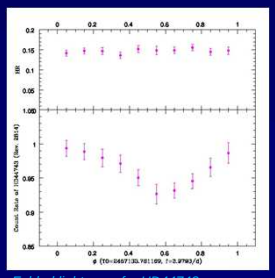
- Step-by-step fits : low-res only, then high-res only freeing abundances of elements with detectable lines, then all data together
- Absorptions: no circumstellar absorption needed, as usual for "normal" B stars
- Temperatures: rather low (0.2-0.6keV), except for HD36960, HD79351 and HD144217 where a component with kT > 1keV exists
- Log(Lx/Lbol): for earliest types = -6.75..-7.37, for latest types, <-7.3
  except for HD79351 (which underwent a flare: companion?)
- Abundances: best match with optical determinations for HD36512,
  but often different values…

3) Lightcurves

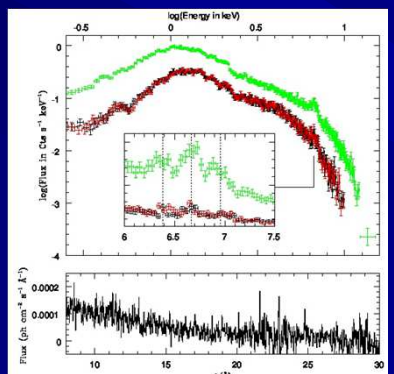
- χ^2 tests
  - Constant objects: HD34816 & HD38771
  - Marginally variable cases: HD35468, HD44743, HD63922, & HD144217
  - Significantly variable targets: HD36512, HD36960 (~parabola), HD52089, HD79351 (~flare), & HD158926
- Period searches
  - Nothing coherent
- Known periods: orbits (but long) & pulsations
  - Folding reveals a clear modulation for HD44743 but only a moderate one for HD158926
- Long-term : comparison with ROSAT count rates
  - Only three cases with significantly different fluxes (HD35468, HD36512, & HD158926) : due to binarity ?

X-ray lightcurves, with the mean shown by the red dotted line.

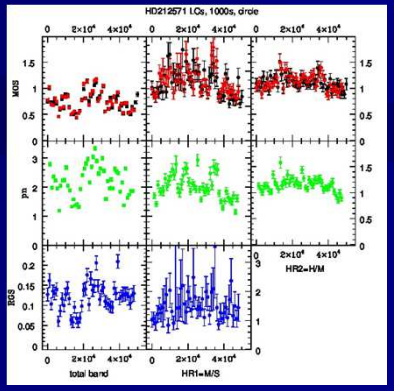


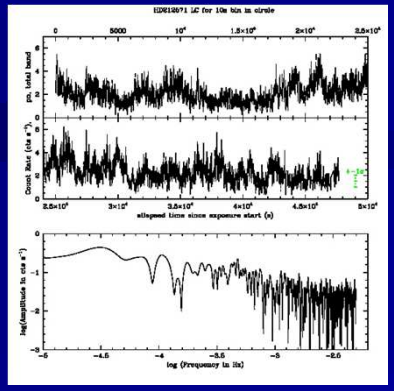


Folded lightcurve for HD44743



Top right: EPIC (pn in green, MOS in red/blakc) and RGS spectra of π Aqr, with a close-up showing the iron complex; Bottom left: lightcurves of π Aqr with 1ks bins; Bottom right: pn lightcurve of π Aqr with 10s bins and associated periodogram.





A new γ-Cas analog

(Nazé et al. 2017, A&A, letter, in press)

- The target list of our survey included a B-star with a high count rate in XMM slew survey (ROSAT count rate just below the cutoff): π Aqr, a varying Be star rotating half-critically
- It was observed in mid-November 2013
  - Data were reduced with SAS v16, filtered for flares
  - Pile-up possible : epatplot exercise negative but data extraction in both a circle and an annulus for safety
- RGS & EPIC: spectra quite featureless, except for the marginal presence of NVIIλ24.8Å and the iron complex: flurorescence line at 6.4 keV and the ionized lines at 6.7 and 7.0 keV → thermal but hot !
- Spectral fitting
  - Main temperature: 10-12keV
  - Local absorption needed
  - Iron subsolar
  - Log(L_x/L_{bol})=-5.5

  → too hot, absorbed and bright for intrinsic (wind) emission but not bright enough for HMXB

  → typically γ-Cas !
- Lightcurve
  - Short (min – flare-like) and intermediate (hour) variations, but no periodicity
  - Long (./. ROSAT, slew survey) changes too !

  → typically γ-Cas !
- Impact on our understanding of the γ-Cas phenomenon
  - π Aqr is a binary but companion ≠ compact and in close orbit ./. disk → no room for a compact accreter
    → γ-Cas phenomenon arises in Be star & its disk…

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