X-rays from M33 and Arp 220

1 The science

1.1 Questions

- Question: what is the typical population of X-ray sources in a galaxy?
- Question: Are certain types of sources associated with certain regions?
- Question: Where is the hot gas in galaxies?
- Question: What is the source of diffuse X-ray emission in galaxies?

1.2 Processes

- X-rays from stellar processes (corona, etc): too faint
- X-rays from recombining photoionized or shocked gas
- X-rays from thermal bremss. and synchrotron - hot gas
- X-rays from accretion sources: WD binaries, CVs
- X-rays from accretion sources: HMXBs, LMXBs
- X-rays from AGN

1.3 Binaries

- NS LMXBs: evolved, old systems; Porb = min to days Disk plus boundary layer or (Fabian-Ross) Compton-reprocessed power law.
- NS HMXBs: High mass companion: associated with recent star formation, short lived. Wind driven
- High L NS HMXBs: disk powered cases
- BH LMXBs
- BH HMXBs

1.4 Extended emission

- Superwinds: X-rays from interior of bubble or from interaction with IGM?
- Correlation with H-alpha
- Mergers: star formation in tidal remnants?

2 X-ray data analysis

2.1 X-ray CCD analysis

- CCD reductions: darks, bias, flat field, bad pixels, cosmic rays, sky subtraction
- X-ray CCD special fun: event detection, pileup, grade selection, energy measurement
- Aspect solution; BI/FI chips; Spectral analysis

2.2 The Fundamental Equation of X-ray Astronomy

$$\begin{aligned} N(p) &= \Delta t \int dE F(E) A(E) R(E,p) \\ \text{PHA FILE} &= \text{EXPOSURE} * \text{MODEL} * \text{ARF} * \text{RMF} \end{aligned}$$

- Convert from detector channel p to energy E using response matrix R (spectral equiv. of PSF).
- Problem: R is not diagonal - cannot invert uniquely
- Problem: A, R depend on position on chip
- Problem: Telescope is moving! Source smeared
- 'Aspect solution' means α, δ, roll angle versus time

$$N(p,i,j,t)dt = \int dE \int d\Omega(\alpha,\delta) F(E,\alpha,\delta,t) A(E,i,j) R(E,p,i,j) PSF(\alpha - \alpha_0(i,j,t), \delta - \delta_0(i,j,t))$$

- Approach: calculate mean spatial calibration
- Then forward fold spectral calibration
- Always work in count space, retain Poisson statistics