Hunting explosive events with the SKA

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Transient hunting facilities

Current facilities:

- Swift-BAT (Hard X-rays)
- MAXI (Soft-X-rays)
- Palomar Transient Factor (optical, 1.2, 7.7 Deg$^2$)
- Catalina Real-Time Transient Survey (optical, 0.5-1.5m, 1.2-8.1 Deg$^2$)
- Pan-STARRS (optical, 1.8m, 3 Deg$^2$)
- SkyMapper (Optical, 1.35m, 5.7 Deg$^2$)
- IceCube (Neutrinos)
- Advanced LIGO (Gravitational Waves)

Future facilities:

- Large Synoptic Survey Telescope (Optical, 6.7m, 9.6 Deg$^2$)
- eRosita (Soft X-rays)
- SKA (inc. ASKAP, MeerKAT, SKA-mid, SKA-low)
Known Radio Transient Sky

- Pulsars (inc. RRATS, Giant Pulses, Transitional XRBs, Magnetars)
- Fast Radio Bursts
- Exoplanets/Brown Dwarfs
- Flare Stars
- Cosmic rays (Lunar interactions)

- CVs
- X-ray binaries
- ULXs
- Tidal Disruption Events
- Intra-day variables/Extreme Scattering Events
- After glows (Supernova, GRBs, FRBs?, Gravitational Waves?)
X-ray/radio correlation of XRBs

The diagram shows a scatter plot with the X-ray luminosity in the 1-10 keV range on the x-axis and the radio luminosity at 5 GHz on the y-axis. Various sources are plotted, each represented by a different symbol and color, indicating their luminosity and radio properties. The plot includes lines of constant radio-to-X-ray luminosity ratio (\( \zeta \)) for different values, such as \( \zeta = +0.7 \) and \( \zeta = +2.0 \). Distances in kiloparsecs (kpc) are also indicated for some sources.
X-ray/radio correlation of XRBs
The radio luminosity is related to the power of the jet

Assume the jet forms a linear inter-dependency with the mass accretion rate

We therefore can use the compact jet to scale the mass accretion rate
A geometrically thin disk can efficiently radiate heat

Bolometric luminosity is linearly proportional to mass accretion rate

\[ L_X \propto \dot{m}_\text{in} \]

Shakura & Sunyaev (1973)

Alternative accretion models have been used to describe low/hard state in XRBs

Geometrically thick disks heat energy is lost through Radiatively inefficient accretion flows (RIAFs)

\[ L_{X-\text{ray}} \propto \dot{m}_{\text{in}}^2 \]

Rees et al. (1982);
Abramowicz et al. (1995)
X-ray/radio correlation of XRBs
If the radio Vs X-ray correlation is a function of mass, where are the intermediates?

Plotkin et al. (2012)
Ultra-Luminous X-ray sources (ULXs)

ULX Holmberg II X-1
Cseh et al. (2014)

NGC 2276 ULX-3
Mezcua et al. (2013)
Analogous to a Super Eddington SS433/W50? (>1 L_{Edd})

Galactic black hole SS433 (JVLA 43 GHz)

Rushton et al.

Dubner et al.
ULXs in the local universe

Maximum distance SKA will detect $10^{33}$ erg s$^{-1}$ ULX bubbles

A. P. Rushton, Oxford University, 2014
Super-Eddington Stellar BHs

ULX Holmberg II X-1
Cseh et al. (2014)

NGC 2276 ULX-3
Mezcua et al. (2013)

ESO 243-49 HLX-1
Webb et al. (2012)
Bursty emission in nearby galaxies

SKA sensitivity to known types of accretion in nearby galaxies

- HLX-1, NGC 2276, Arp 220 transients
- IC342 X1, M83 (MQ1), NGC 7793 (S26)
- M82 transient
- B0168+65 (X1)
- NGC 5477 X9
- W50 (SSID)

Radio luminosity (erg s^{-1})

Distance (Mpc)
Highly Variable source: V404 Cyg

June 2015: few mJy -> few Jy in days

4 PI SKY team
Highly Variable source: V404 Cyg

June 2015: few mJy-> few Jy in days

4 PI SKY team
Highly Variable source: Cyg X-3

Source Varied between 0.1-20 Jy on time-scales of a few days

- Very poor images due to intrinsic changes in the sky brightness
- Violating a basic assumption of aperture synthesis
Extreme simulated effect of source variation

A 1 Jy Gaussian component convolved with the eMERLIN beam (5 GHz)

Concatenated with a 0.1 Jy component

Result
• The RMS noise of the map increases by a factor of 10-100
• Bad side-lobes affects the fidelity of the map
Automatic triggering

- Monitor known transient with AMI
- Report variability via VOEvent (XML)
- Robotically respond at higher resolution (VLBI/EVN)
Figure 5. VLBI maps of XTE J1908+094 during an X-ray state transition (note: the top panels span 4 days and the bottom is scaled over 1.7 days). L and P are the lowest and peak contours in units of mJy bm with contour levels of \((p^n, w)\), where \(n = 3, 4, 5, 6, \ldots\). The circle indicates the estimated position of the binary and the white line shows the extrapolated positions of the respective components.
Thanks