PROCEEDINGS OF SCIENCE

Optical polarisation of the black hole candidate A0620-00: clues on the geometry in quiescence

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The optical light from LMXBs may be intrinsically polarised if it arises from synchrotron emission or if it is scattered within the system. We report on the polarisation properties of the black hole candidate A0620-00 in quiescence. The optical polarisation is weakly variable on the orbital period. Spectro-polarimetry suggests the polarisation might arise from scattering onto material sitting outside of the system.

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1. Introduction

Light can be measured for its direction, its variability, its spectrum and also for its polarisation properties, the latter being oft-neglected. Several processes can lead to significant linear polarisation of the visible light coming from a compact binary:

1. light propagation through the interstellar medium
2. light scattering within the system (of companion light onto the accretion disk/stream or vice-versa)
3. synchrotron emission from particles in a sufficiently well-ordered magnetic field (jet?)

The information brought by the measurement of the linear polarisation brings constraints on (respectively to the above)

1. extinction and distance
2. the system geometry (e.g. inclination i)
3. the contribution of non-thermal (jet) emission in the visible

Measuring the polarisation fraction of visible light is a very reasonable endeavour yet, and despite the above, surprisingly few observations have been reported. Dubus & Chaty (2006) studied polarisation from three microquasars (X-ray binaries displaying relativistic jets), reporting a tentative detection of intrinsic near-IR polarisation from XTE J1550-564 while it was undergoing a mini-outburst, likely originating in a compact jet (Chaty, Dubus, Raichoor in prep.). Investigations in visible and near-IR have also been carried out by Schultz et al. (2004), Shahbaz et al. (2008) and Russell & Fender (2008). Russell et al. find intrinsic near-IR polarisation during an outburst of GRO J1655-40.

2. The black hole candidate A0620-00

A0620-00 is a low-mass X-ray binary discovered during a major outburst in 1976. It has since been in quiescence. A0620-00 is the prototypical soft X-ray transient. It is one of the best studied black hole candidates. Dolan & Tapia (1989) reported p_V=3% with a Δp =2% modulation on the orbital period of 7.8 hr. Such a modulation is expected if the polarisation arises from scattering and is then caused by the changing aspect seen by the observer. The polarisation vector then traces an ellipse in the Stokes (q,u) plane whose eccentricity gives a measure of the system inclination. Polarimetry can bring a new, independent constrain on i. The system inclination is a crucial parameter to estimate the mass of the black hole and is usually constrained by modeling of the ellipsoidal modulation. The error on the inclination decreases as the ratio $\Delta p/\sigma_p$ increases and this poster presents the result of observations designed to carry out this measurement.

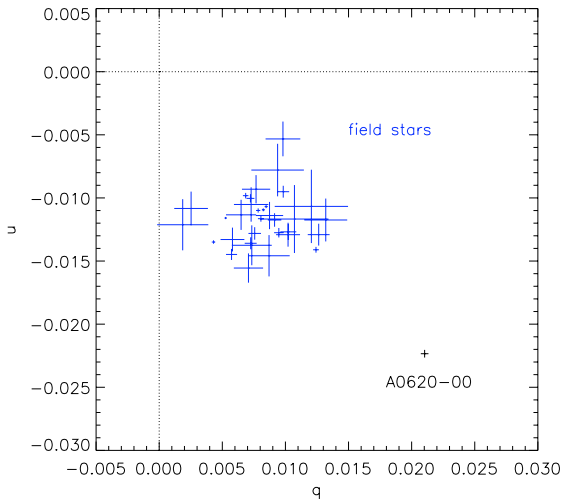

Figure 1: Average polarisation of A0620-00 (black) and nearby stars (blue) in the Stokes (q,u) plane. The stars are selected for $p/\sigma_p > 5$ (i.e. significant polarisation) in the 5'×5' field-of-view of EFOSC-2.

3. Observations

V-band polarimetry of A0620-00 was obtained during three nights at the ESO 3.6m using EFOSC2, covering several orbits. The Stokes parameters q and u were derived from series of exposures taken at four different angles in the V band by rotating the half-wave plate. Data reduction was checked against several polarimetric standards observed during the same nights. In addition, a single spectropolarimetric measurement was obtained at the ESO VLT using FORS-1.

4. Results

1. A0620-00 is polarised at a higher level than stars in the field: the source displays intrinsic polarisation above the field interstellar polarisation (Fig. 1).

2. The average A0620-00 polarisation is p_V=3.08±0.04%, θ=156.°5 ±0.°4 is consistent with Dolan & Tapia 1989 also taken while the source was in quiescence but 15 years ago. They had found p_V=3.1%, θ=147°.

3. During its 1976 outburst, the polarisation of A0620-00 was smaller, with p_V=1.71±0.16%, θ=142.°4±0.°1 (Dolan, 1976)

4. The mean polarisation of the field stars is $\bar{p}_V$=1.5%, $\bar{\theta}$=153°. The magnitude of the polarisation is consistent interstellar polarisation, as expected from the measured optical extinction $E(B-V)$ to A0620-00.

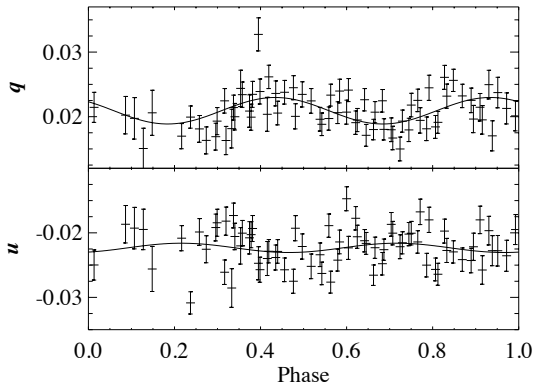

Figure 2: V-band linear polarisation folded on the orbital period (Stokes q and u lightcurves are shown). The amplitude of the orbital modulation, if any, is $\leq$0.2% (fitted line).

5. The outburst p_V measured in A0620-00 is consistent with only ISM polarisation, suggesting the source of the intrinsic polarisation is related to quiescence or is caused by something that appeared during/after the 1976 outburst.

6. The 2% modulation in Dolan & Tapia (1989) is not confirmed. The polarisation is modulated at a level $\leq$0.2% and is too small to constrain i.

7. The lightcurve shows strong flares on hour timescales (e.g. Hynes et al. 2003) with no clear correlation with the Stokes parameters: this argues against flares of highly polarised synchrotron emission.

8. The polarised spectrum shows no variation of (q,u) across strong lines (Hα), suggesting the whole spectrum from the system is scattered.

5. Conclusion

Based on the above, the intrinsic polarisation could arise due to scattering onto material ejected during the outburst which has settled on circumbinary orbits. In support of this speculation, infrared emission in excess of expectations from an accretion disk + companion star has been measured by Spitzer while the system was in quiescence and interpreted as circumbinary material (Muno & Mauerhan, 2006).

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