PRE-MAIN SEQUENCE DWARFS NEAR γ VELORUM.

K.W. Smith[1,2], M. Güdel[1], M. Audard[1], and R.D. Jeffries[3]

[1]Paul Scherrer Institut, Würenlingen and Villigen, CH-5232 Villigen PSI, Switzerland
[2]Institute of Astronomy, ETH Zürich, CH-8092, Switzerland
[3]Department of Physics, Keele University, Keele, Staffordshire ST5 5BG, UK

Abstract

We present an analysis of EPIC pn and MOS exposures of the young cluster near the Wolf Rayet + O8 binary Gamma Vel, at the centre of the gamma Vel OB2 association. We detect 107 sources which are suspected to correspond with optically detected PMS stars. These young objects are known from ROSAT data to be unusually X-ray bright compared to nearby T-association objects, and it is therefore expected that they will exhibit correspondingly high levels of flaring activity.

Key words: Stars: active - stars: T Tauri

1. Introduction

Low mass pre-main sequence stars evolve through a disc accretion phase as they contract towards the zero-age main sequence. Material accretes through the disc and eventually is either deposited on the star, coalesces into a planetary system or is blown away in an outflow. According to standard models, accretion onto the star is dominated by strong stellar magnetic fields which channel the material from the inner disc edge through a magnetosphere onto the star's surface. This process is thought to regulate the spin period of the star, since it mitigates the spinup torque due to the accreting material and may provide some spindown torque by magnetic coupling to the disc outside the corotation radius. Furthermore, feedback processes can be envisaged; spinup of the star would increase the strength of magnetic fields and force the disc edge outwards, reducing the spinup torque. Conversely, spindown would reduce the field strength and hence the disc edge could move in, increasing the spinup torque. In the nearest low mass star forming region to the Sun, the Taurus-Auriga T-association, accreting stars with discs are found to rotate less rapidly than their non-accreting counterparts, the opposite situation to that expected.

Stars always form in groups. Two types of star formation region are identified in the Solar neighbourhood. T-associations, such as the aforementioned Taurus-Auriga dark cloud, and OB associations, such as the Orion nebula. It is not clear whether these represent two distinct star forming modes, whether there is some continuum between the extremes, or whether the presence of O and B stars is more or less a matter of statistics (a more massive and populous region has more chance of containing rare massive stars). It is also not clear how many low mass stars form in each type of environment (clearly all O and B stars form in OB associations). This question is of more than passing interest because the UV radiation field of hot O and B stars can have dramatic effects on the circumstellar material of the lower mass stars (witness the evaporation of the discs in Orion). This could affect the rotation properties of the stars, the strength of jets and outflows, the ability to form planets, the masses of any planets which do form, and their tendency to migrate through the disc and become 'hot Jupiters'.

2. The γ Velorum T-association

Recently, an association of young, low mass stars was found in the vicinity of the Wolf-Rayet + O8 binary γ Velorum, a member of the Vela OB2 association (Pozzo et al, 2000). These objects were found to be unusual in that they were extremely X-ray luminous compared to other groups of low mass pre-main sequence stars (see Figure 1).

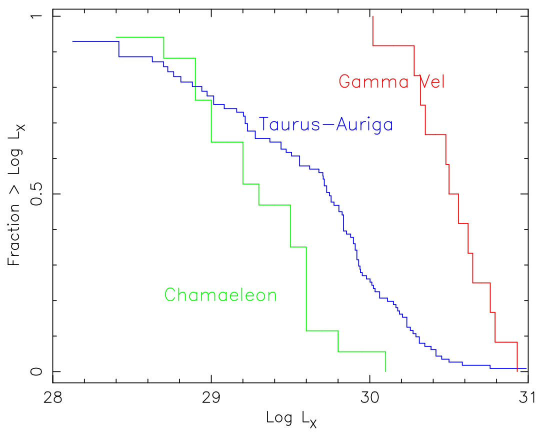

Figure 1. X-ray luminosity functions for Chamaeleon, Taurus Auriga and γ Vel T associations. The difference between Chamaeleon and Taurus Auriga may indicate an evolutionary effect. The luminosities are calculated assuming a distance of 410pc, but even if corrected for the smaller Hipparcos distance the γ Velorum stars are overluminous.

Proc. Symposium *'New Visions of the X-ray Universe in the XMM-Newton and Chandra Era'* 26–30 November 2001, ESTEC, The Netherlands
ESA SP-488, August 2002 eds. F. Jansen & TBD

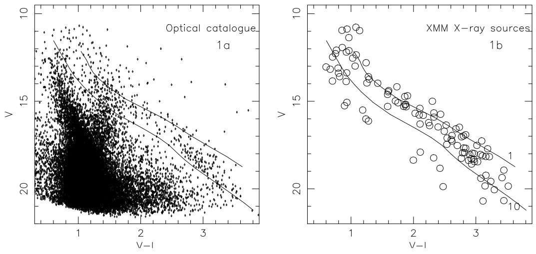

Figure 2. Left: HR diagram of optical sources in the field. Right: The identified X-ray sources. These are the closest (within 6 arcsec) X-ray counterparts to optical sources which lie within three magnitudes of the cluster main sequence.

This overluminosity is greater than could be attributed to any distance uncertainty [there is some controversy over whether γ Velorum is located at a distance of 260 pc (from *Hipparcos* parallaxes) or 410 pc (the mean distance to Vela OB2), and which of these distances applies to the dwarfs]. Greater X-ray luminosity is of course an indicator of enhanced magnetic activity, which in turn would indicate generally faster rotation rates. Could it be that the proximity of these objects to γ Velorum and its UV field has stripped away the circumstellar material, allowing these objects to spin up and so develop stronger magnetic fields than their counterparts elsewhere?

The image below is one of a number of XMM-Newton exposures we obtained of the γ Vel field. 107 sources from the exposure have been identified with optical counterparts (criterion: optical object lies within three magnitudes of cluster main sequence and within six arcsec of position of X-ray source, closest object is best in the event of confusion). The catalogue of optical sources and the identified X-ray sources are shown in Figure 2. Deeper optical exposures are planned, with the goal of extending the mass range down to substellar objects. The addition of MOS data and further XMM exposures will also allow us to go deeper in the X-ray field. To address the question of rotation and accretion, two sets of optical observations will be made. Firstly, a search for spectral accretion signatures, which will indicate whether the γ Vel objects really lack discs in general. Secondly, a search for rotation periods less than 4 days will be made. If most objects are found to have rapid rotation periods, this will tie in with the X-ray properties and also (by implication) with the idea of absent discs. The greater sensitivity of XMM compared to previous missions also allows us to make a systematic search for flaring behaviour and to analyse spectral characteristics of these sources. Several examples of strong flares are shown in Figure 2. The corresponding objects to these lightcurves are indicated on an EPIC pn frame.

References

Pozzo et al, 2000, MNRAS 313, L23

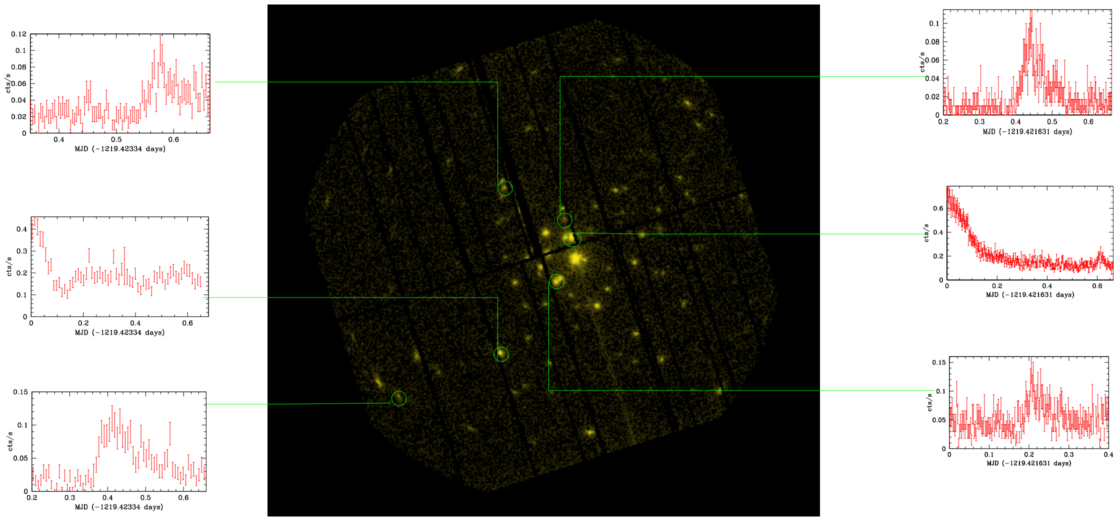

Figure 3. EPIC pn frame showing the γ Vel cluster. γ Vel itself is the bright star in the centre. Several lightcurves showing flaring behaviour are plotted, with the corresponding sources indicated in the EPIC frame.