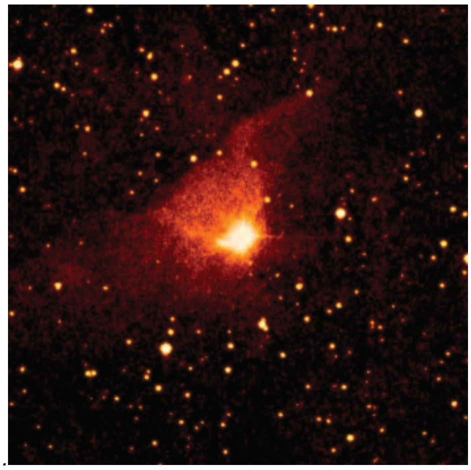
The FU Orionis phenomenon

FU Orionis stars are pre-main-sequence eruptive variables which make up a small class of young low-mass stars appear to be a stage in the development of T Tauri stars. They gradually brighten by up to six magnitudes over several months, during which time matter is ejected, then remain almost steady or slowly decline by a magnitude or two over years. All known FU Ori stars (commonly known as fuors) are associated with reflection nebulae. The article gives a brief description of this kind of objects.

FU Orionis is somewhat 1600 light-years away and associated with a reflection nebulae in the Orion constellation. It is located about three degrees NW of Betelgeuse, and less than a degree east of the small planetary nebula NGC2022. FU Orionis is the prototype of a class of young stellar objects (YSOs), which have undergone photometric outbursts on the order of 4-6 mag in less than one year (Herbig 1966). These stars are still in the process of forming, accreting gas from the clouds they formed from. The first outburst of FU Ori was observed in 1936-37, when an ordinary undiscovered 16th magnitude star began to brighten steadily. Unlike novae bursts, which forth suddenly and then begin to fade within weeks, the FU Ori kept getting brighter and brighter for almost a year being around 10th magnitude ever since.

Typically, FU Orionis star's luminosity peaks at approximately 500 luminosities of the Sun and then appears to decay for decades. FU Orionis stars exhibit large infrared excesses, double-peaked line profiles, apparent spectral types that vary with wavelength, broad, blueshifted Balmer line absorption, and are often associated with strong mass outflows. For more details on this phenomenon please refer to Hartmann & Kenyon (1996).

The FU Orionis stars have been convincingly modeled as low-mass pre-main-sequence stars (similar to T Tauri stars) that are surrounded by luminous accretion disks. Such systems demonstrate that disk accretion in early stellar evolution is highly episodic. It seems that the phenomenon is restricted to early phases of stellar evolution. Steady accretion disk models successfully explain many observations of the FU Orionis. Photometrically FUors are characterized by violent and probable recurrent outbursts.



FU Orionis and its associated nebula. Image credit: ESO

Since the outburst of FU Ori itself in 1936 (Wachmann 1954; Herbig 1966), only a small number of other FUor outbursts have been discovered, notably V1057 Cyg and V1515 Cyg (Herbig 1977). The light curves of these three best studied FUors show remarkable differences between each other (Vittone & Errico, 2005). In 1969, a star embedded in the "East Texas" region of the North America Nebula (NGC 7000) jumped from 16th to 10th magnitude.

The star, V1057 Cygni, attained maximum luminosity in mid-1970, and afterwards it slowly faded; it now lies three magnitudes below peak brightness. A number of objects are known that are spectroscopically similar to FUors, but for which the outburst phase has not been documented. Spectroscopically, FUors have no-emission-lines spectra with optical characteristics of G-type supergiants, yet near-IR characteristics of cooler K- or M-type giants/supergiants dominated by deep CO overtone absorption (Vittone & Errico, 2005).

Researchers led by Jean-François Donati of the Observatoire Midi-Pyrénées in Toulouse, France, have observed the magnetic fields in the central regions of a disc around FU Orionis. They used a new high-resolution instrument called ESPaDOnS on the Canada-France-Hawaii Telescope (CFHT) in Hawaii to detect polarised light (*due to the magnetic fields*) from the disc. The magnetic fields surrounding a young star have been detected for the first time. Several of fuors were also discovered in the past years, including those from the data of the Catalina Real-time Transient Survey. One more remarkable addition is the embedded protostar V1647 Orionis which erupted in January 2004.

About ten FU Orionis objects are currently known. Others almost certainly lurk undiscovered among the stars in the Herbig-Bell Catalog, provided on-line by Karen Strom at UMass. *For more information on these interesing and rare objects please refer to the list of resources published in this issue on the page 24.*

Ivan Adamin

the appropriate amount of shots with the same exposures. Making the Flat files is a little more complicated. Ideally, they are easy to get on evening or predawn twilight sky. You need to choose the exposure to get a ¼ - ½ of the value of complete saturation of the pixel. For example, full saturation for 16 bit camera is 65535. The value of a pixel in the Flat file should be in the range of 15.000 – 30.000. I use 20.000.

Another way of obtaining the Flat files is to use the so-called flat-box. I use a white screen which is attached to the dome. Am bringing him a telescope and the illuminating light bulb. For more scattered light, the telescope tube can be covered with a white cloth. Flat files must be taken separately for each filter. The number of calibration frames depends on a particular camera model. I usually make 15-20 frames of each type.

Once the calibration files are completed, the observational data can be processed. The first step is to calibrate frames containing the target object using the same calibration files. At this step we get a clear picture without any unnecessary noise content. The second step is photometry measurements. Don't forget to specify multiple comparison stars and their brightness in the range the data frames are.

With a series of photometric observations, we can build a light curve, find the period of a variable star, other parameters, depending on the variability type.

There are lots of software to make the analysis of the photometric data. A good example is a software package created by Andrey Prokopovich and Ivan Adamin (the VS-COMPAS project core team). There are desktop and web versions available. It is a powerful software that allows you to build the light curves, search for possible periods, combine data from a number of photometric surveys and more.

I would also like to mention another program called MCV created by professor I.L.Andronov. The program is unique in its kind and allows you to make a very accurate and detailed analysis of the photometric data.

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The FU Orionis phenomenon: further reading (references) – see p.3 for the article

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- Discovery of possible FU-Ori and UX-Ori type objects; online: http://crts.caltech.edu/CSS091110.html
- FU Orionis Stars; online: http://www.astro.umd.edu/~neal/fuori.html
- FU Orionis; online: http://www.nightskyinfo.com/archive/fu_orionis/
- The Herbig-Bell Catalog; online: http://www.stsci.edu/~welty/HBC/HBC.html
- The Furor over FUORs; online: http://www.universetoday.com/78796/the-furor-over-fuors/

The VS-COMPAS Project

The project was started in fall of 2011 by four amateur astronomers from Belarus. The main intention is to expand the International Variable Star Index (VSX) catalog with new variable stars, variable stars data analysis and research. Among the most significant achievements it is worth to mention more than 1200 variable stars discovered by combined efforts of seven active team members. All data about discovered stars is submitted to the VSX catalog running by the AAVSO. Another valuable goal the project has is increasing public interest to variable stars science.

More information about the team and discoveries can be found at http://vs-compas.belastro.net