PRESS RELEASE

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Hungry Young Stars: A New Explanation for the FU Ori Outbursts

Astronomers are announcing today the result of new computer simulations which reveals a burst phenomenon that explains the transient brightenings of FU Ori variables. This work is being presented by Prof. Shantanu Basu and Dr. Eduard Vorobyov of The University of Western Ontario, in London, Ontario, Canada, to the 207th meeting of the American Astronomical Society in Washington, DC. This result is of special interest because it reveals a new physical process by which young stars accumulate their mass and protoplanets can be formed or destroyed.

The scientists at UWO have shown that protoplanetary embryos forming within a gas disk surrounding a young star are episodically driven into the star. Like the process of throwing logs into a fireplace, these episodes of embryo consumption produce excess energy which causes the young star to temporarily brighten by a factor of hundreds to thousands. As a result, the early life of a star should be peppered with colossal bursts of luminosity, resembling what is observed in the FU Ori variables. During each burst episode that lasts about 100 years, the star is consuming the equivalent of one Earth mass every ten days. After this, it may take another several thousand years before another event occurs.

A steady energy input from the Sun for billions of years favored the birth of life on our planet. However, young stars can lead tumultuous lives. The FU Ori variables are named after the prototype young star FU Orionis, located at a distance of about 1500 light years in the constellation Orion. Stars of this type exhibit a rapid brightening by a typical factor of several hundred in the course of a year, followed by a gradual decline that can take decades. If surrounded by a planetary system like ours, an FU Ori star in its outburst phase would turn Earth into a burnt crisp but could make Pluto into a tropical paradise.

“It is cannibalism on an astronomical scale," says Dr. Eduard Vorobyov, CITA National Fellow at UWO, adding that “the protoplanetary embryos are like the offspring of the parent star, but they are swallowed up before they have a chance to mature, possibly into giant planets like Jupiter.” The protoplanetary embryos are formed within spiral arms that are created by gravitational instabilities in the disk. The instabilities are driven by the continuing rain of matter coming in from the surrounding gaseous nebula. Unfortunately for the embryos, the gravitational interaction with the spiral arms results in their being driven into the central star. “As one generation of embryos meets its demise, a following generation is born and meets its doom as well. The process keeps repeating as long as there is enough matter raining onto the disk,” says Dr. Vorobyov.

Figure 1 is an image of the density of a gas disk surrounding a young star, which is shown by the central bright circle. The disk is viewed face-on. Note the bright points which represent the embryos, and the spiral arms. This image represents a snapshot in time. An animation of the long-term temporal evolution of the disk, which includes the burst phenomenon, can be downloaded from http://www.astro.uwo.ca/~basu/aas207/. The animation clearly shows the repeated formation of embryos and that they are often driven onto the star. The lower panel in the animation tracks the rate at which mass reaches the star, and provides dramatic confirmation of each burst event.

Figure 2 shows the time history of the luminosity of the young star. There is an early smooth behavior of luminosity between t = 0, when the star forms, and t = 8000 years, when the surrounding gas disk forms. The later evolution clearly shows the bursts in luminosity of the star, as individual episodes of protoplanetary embryo consumption take place. The luminosity rise can be a factor of hundreds to thousands during these episodes. The frequency of bursts decreases as the amount of matter raining onto the disk declines.

These findings are significant because they "reveal how star and planet formation are driven by the influence of a surrounding nebula," says Prof. Shantanu Basu. The newly discovered burst phenomenon ultimately stops when there is little mass left to fall onto the disk surrounding the young star. "It is possible that the last generation of embryos will survive to form planets, brown dwarfs, or companion stars, depending on their mass," says Prof. Basu, adding that "future calculations will reveal the answer."

The UWO team has been supported by a grant from the Natural Sciences and Engineering Research Council of Canada, a Fellowship from the Canadian Institute for Theoretical Astrophysics, and a Fellowship from the North Atlantic Treaty Organization. Some computer simulations were carried out on the Shared Hierarchical Academic Research Computing Network.

EDITORS: This press release, as well as Figure 1, Figure 2, and an animation of the disk evolution, can be downloaded from http://www.astro.uwo.ca/~basu/aas207/ as soon as the embargo expires.

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FIGURES

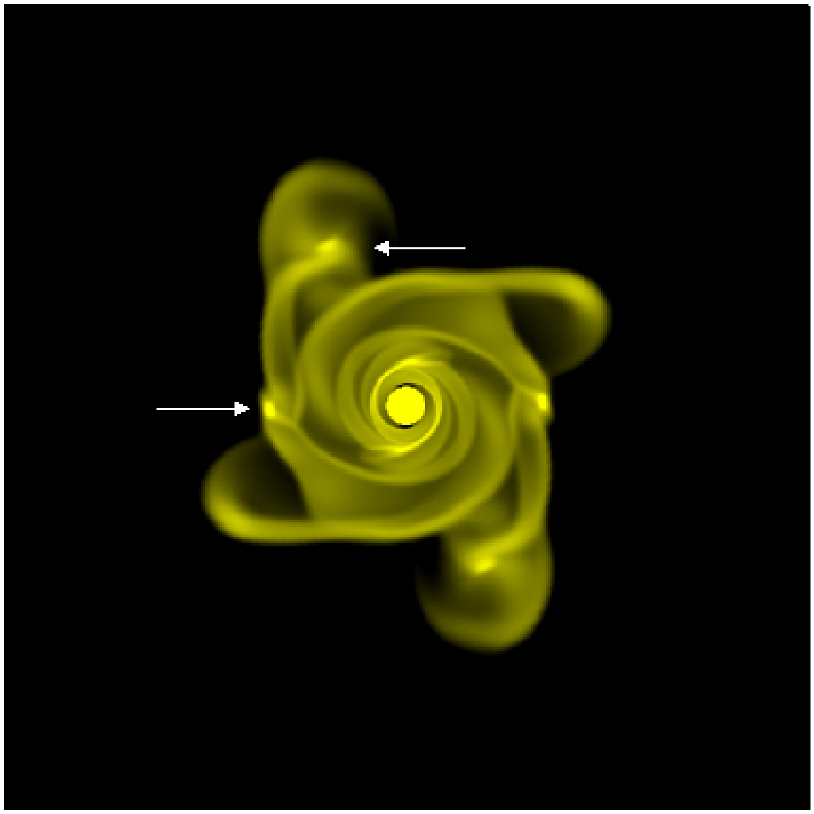

Figure 1: An image of the gas disk surrounding the young star.

The star is represented by the central bright circle. The black background contains matter that is falling onto the disk but cannot be seen due to its low density. Note the spiral arms and dense bright clumps within them. The latter represent protoplanetary embryos which are often driven onto the star. Arrows identify the location of some embryos. An animation of the time evolution of the disk can be downloaded from www.astro.uwo.ca/~basu/aas207/.

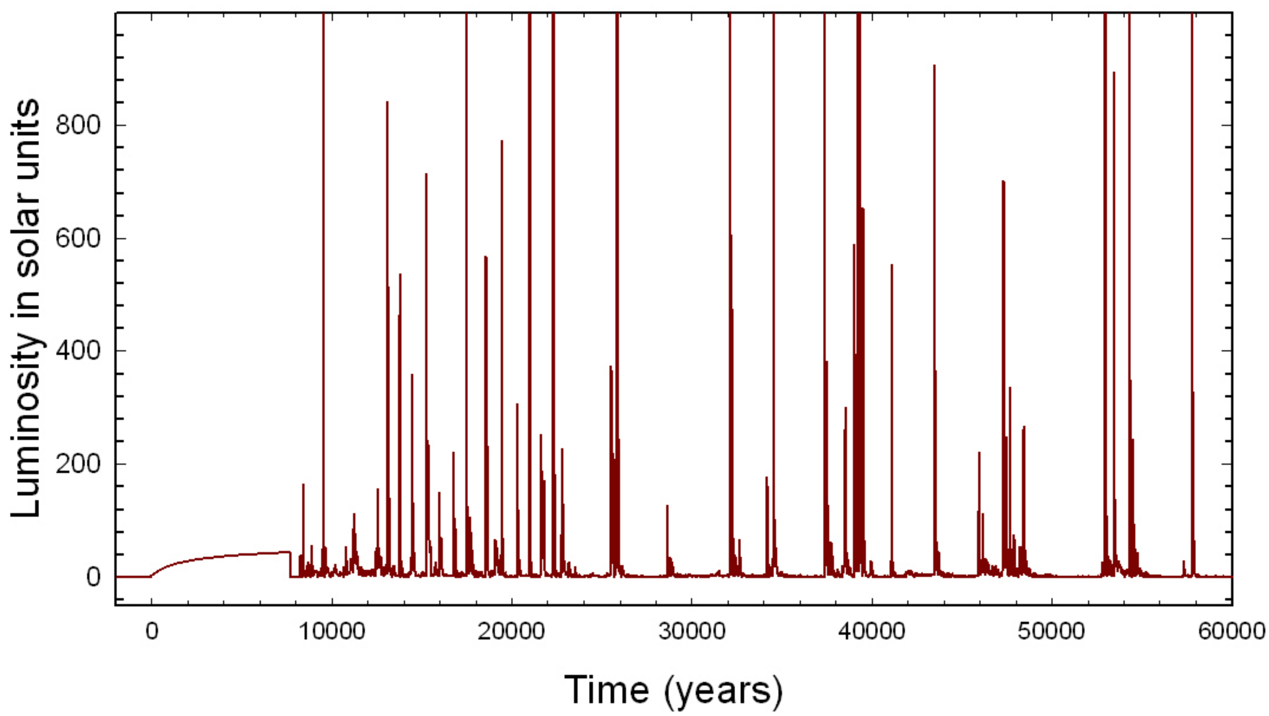

Figure 2: Estimated luminosity evolution of a young star.
The time $t = 0$ represents the formation of the star. Note an initial smooth behavior of luminosity. However, when the gas disk forms around the star at $t = 8000$ years, the luminosity exhibits colossal bursts associated with embryo consumption.