German researchers discover exotic 'dark clusters' in their calculations

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(PhysOrg.com) -- Theoretical physicists at the University of Bonn propose a new class of celestial bodies: “Dark Star Clusters”, consisting of many black holes and some stars orbiting around each other. So far, such a structure is a hypothesis, but they could lead to deeper insights into supernovae explosions, gravitational wave generation and the evolution of star clusters. The scientists published their results in the *Astrophysical Journal Letters.*

Stars evolve from gas clouds, which contract very deeply due to their own gravity to start the solar fire. Only rarely are the stellar objects loners, they usually form in groups. These star clusters are places in the universe where a particularly large number of luminous gas balls form at once, and where after many millions to billions of years the stars also perish. If such clusters are still young, the dying stars end their lives in supernova explosions that emit extremely bright flashes. “If the masses of the stars are sufficiently large, extremely dense neutron stars and black holes are left over”, says Professor Dr. Pavel Kroupa of the Argelander Institute for Astronomy at Bonn University.

The extreme gravity captures light

In the vicinity of a black hole, the gravitational force is so great that not even light can escape. They are therefore invisible. Astronomers can detect the existence of black holes only when a gas cloud or a star is accelerating in its orbit by their extreme gravity. “Under certain

conditions exceptionally many black holes develop in a star cluster," says Dr. Sambaran Banerjee, who came from the prestigious "Tata Institute of Fundamental Research" in Mumbai (India) to Bonn as an Alexander von Humboldt Fellow. "In these cases, we propose to call them 'dark star clusters', which consist of black holes and some stars circling around each other."

The original question the Bonn physicists wanted to investigate are the physical properties of dying star clusters. Carried out on high performance computers, their calculations surprisingly showed that such "dark clusters" have to form. "The stars in the cluster perform chaotic dances", reports Professor Kroupa. "They attract each other due to gravity and therefore constantly change their path". Gravity binds the star cluster, so that at first the dancers remain together. However, the dance partners evolve. "Over time the lighter stars vaporize", said Professor Kroupa. "The heavier black holes and neutron stars resulting from supernovae, however, accumulate increasingly - the star cluster thereby becomes increasingly darker, because these components do not emit light". This way "dark star clusters" develop. The curtain of the cosmic dance performance thus closes gradually.

A "kick" with some 100 kilometers per second

When a supernova explodes, it can happen that the resulting black holes are greatly accelerated and ejected from the young star clusters. "This 'kick' can have several 100 kilometers per second", says Dr. Banerjee. Thus, the black holes are lost and a "dark cluster" can not develop. "The closer the star cluster is to the center of the Milky Way, the larger is the surrounding gravity", explains Professor Kroupa. Then the light stars can evaporate faster than the black holes kick each other out of the aging star cluster. "Our calculations show that dark clusters can only occur within a distance of about 15,000 light years from the center of the Milky Way", says Dr. Banerjee. Further away the light stars vaporize too slowly, so

the dark phase can not be achieved.

“So far there is no way to verify whether the black holes and neutron stars stay in the star cluster”, adds Professor Kroupa. “Using the dark star clusters, which we propose based on our calculations, this now becomes possible”. A “dark star cluster” can be recognized from the fact that the remaining stars in it are moving much faster than predicted. “The stars seem to be held together by an invisible force or mass”, says Dr. Banerjee. This force is the additional gravity of the black holes and the neutron stars existing in the star cluster.

“Astronomers can now specifically search for dark star clusters”, says Professor Kroupa. “If they are indeed found, then an exotic new class of celestial bodies would be discovered”. “In addition, the star clusters would then be the source of gravitational waves that Einstein predicted based on his general theory of relativity and which is among the most important predictions that the scientists are eager to verify”, adds Dr. Banerjee. “The finding of ‘dark star clusters’ would improve the understanding of the physics of supernova explosions too”, concludes the physicists of the University of Bonn.

More information: Sambaran Banerjee and Pavel Kroupa: A new type of compact stellar population: dark star clusters, 2011, *The Astrophysical Journal Letters*, doi: 10.1088/2041-8205/741/1/L12

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