



Neutron Stars in Open Clusters: (Why) Are they There?

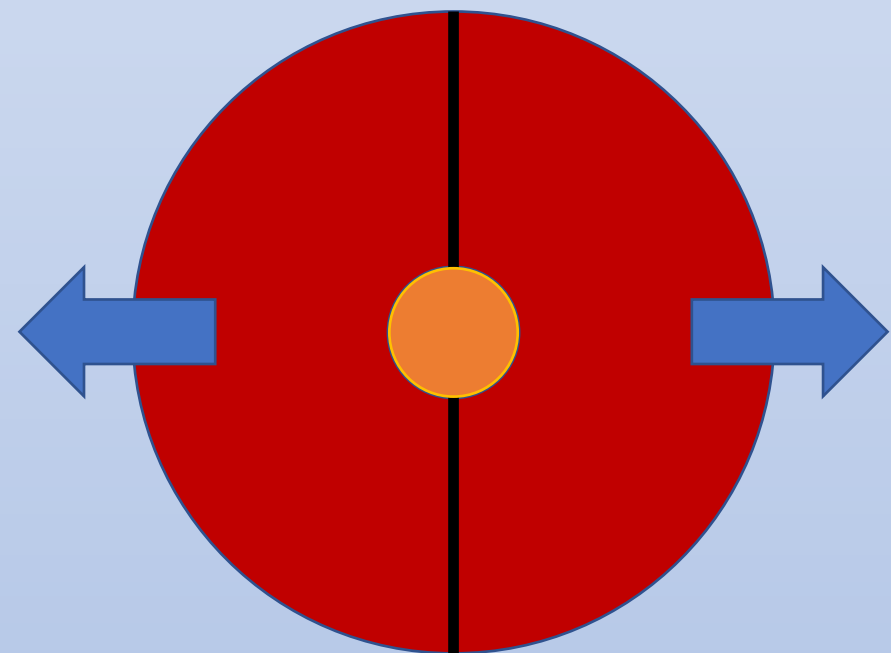
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Neutron Stars

At the end of its lifetime, a star with 10-29 times the mass of the sun will eventually undergo an explosion called a supernova. The iron core of the dying star collapses into an extremely dense stellar remnant called a neutron star.

Supernova Asymmetry

When a supernova occurs, matter is not ejected symmetrically. This imparts a kick velocity on the neutron star in the center.



If the initial mass (red and orange) is 10 solar masses and the neutron star (orange) is 2 solar masses. The left half goes 5000 km/s and the right goes 4995 km/s we can find the kick velocity:

Conservation of momentum: $p_i = p_f$

$$0 = p_{l\frac{1}{2}} + p_{r\frac{1}{2}} + p_{ns}$$

$$0 = -4M_{\odot}(5000km/s) + 4M_{\odot}(4995km/s) + 2M_{\odot}(v_{ns})$$

We find a kick velocity of:

$$v_{ns} = 40km/s$$

X-ray Binaries

When a compact remnant such as a neutron star is in a binary system where the other member of the system is a normal star, the system shines brightly in the X-rays.



The strong gravitational force of the neutron star (left) pulls material off of the normal star (right) into a disk (left) which heats up to millions of degrees kelvin and releases X-ray radiation.

Open Clusters

An open cluster is a group of stars that formed hundreds of millions of years ago and have stayed in the same area. They contain up to a few thousand stars.



The Open Cluster NGC 6819

Escape From Open Cluster

The escape velocity from a gravitational well such as a planet, a star, or a star cluster is the velocity at which:

$$KE + PE = 0$$

For the open cluster NGC 6819, based on a simple model, the escape velocity is:

$$v_{esc} = 1.516km/s$$

Research And Questions

Dr. Natalie Gosnell and others discovered an unexpected number of X-ray sources in the open cluster pictured below, NGC 6819 (Gosnell et al. 2011). One of these X-ray sources had the signature of an X-ray binary system containing a neutron star. Based on the calculations here, detecting a neutron star in NGC 6819 would bring about a big change in the current understanding of open cluster dynamics and neutron star formation. How would a neutron star with a kick velocity of many km/s stay in a cluster with an escape velocity of just a few km/s? Can neutron stars form without a supernova? There is more work to be done to answer these questions.

References

Gosnell et al. 2012, ApJ, 745, 57

Acknowledgments

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