Quantum magnetic collapse of a partially bosonized *npe*-gas: implications for astrophysical jets

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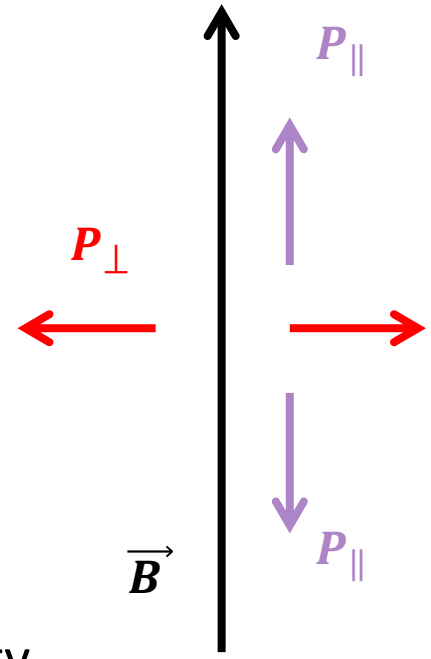
Partially bosonized *npe*-gas: A simple neutron star-type configuration composed by ideal neutrons, protons, electrons (*npe*-gas), and paired (bosonized) neutrons and protons in stellar equilibrium.

Quantum magnetic collapse:

EMT for magnetized quantum gases:

$$T^{\alpha\beta} = (-E, P_\perp, P_\perp, P_\parallel), \quad \alpha, \beta = 0,1,2,3$$



Collapse

$P_\perp \leq 0$ or $P_\parallel \leq 0$
for certain values of temperature, density and magnetic field

E - energy
$P_\parallel$, $P_\perp$ - parallel and perpendicular pressures with respect to the magnetic axis

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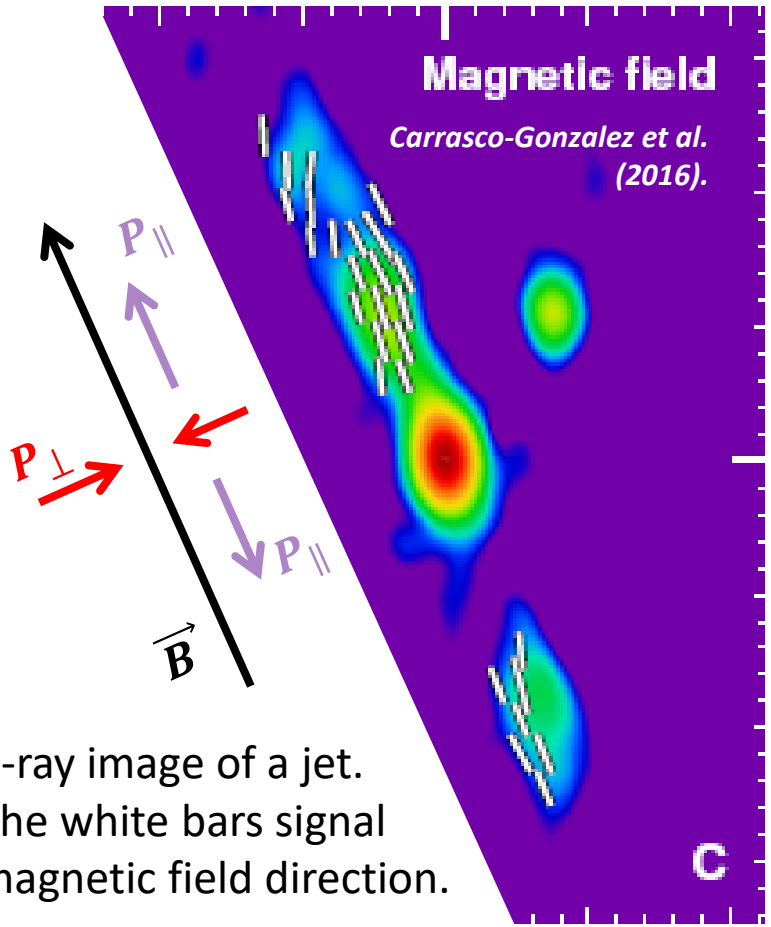
Astrophysical jets: Streams of collimated matter ejected by several astronomical objects, that moves away from their source without dispersing.

The physics mechanisms behind jets are still under debate.

The general consensus is that magnetic fields play has an important role on them, in particular, for collimation.



X-ray image of a jet. The white bars signal magnetic field direction.

Our proposal is that role of magnetic field in jet's physics might be played through the quantum magnetic collapse with $P_{\perp} \leq 0$.

To begin testing our hypothesis, we consider the partially bosonized npe-gas and ask the three following questions:

1. Can $P_{\perp} \leq 0$ for any of the gases in the mixture in astrophysical conditions (magnetic fields$\sim 10^{13} - 10^{18}$G, baryon densities$\sim 10^{11} - 10^{15}$g/cm^3)?
2. Can the parallel pressure of the collapsed gases be greater than the gravitational pressure of the star and lead to the ejection of matter?
3. Once the matter leaves the star, is the magnetic field strong enough to keep it collimated?

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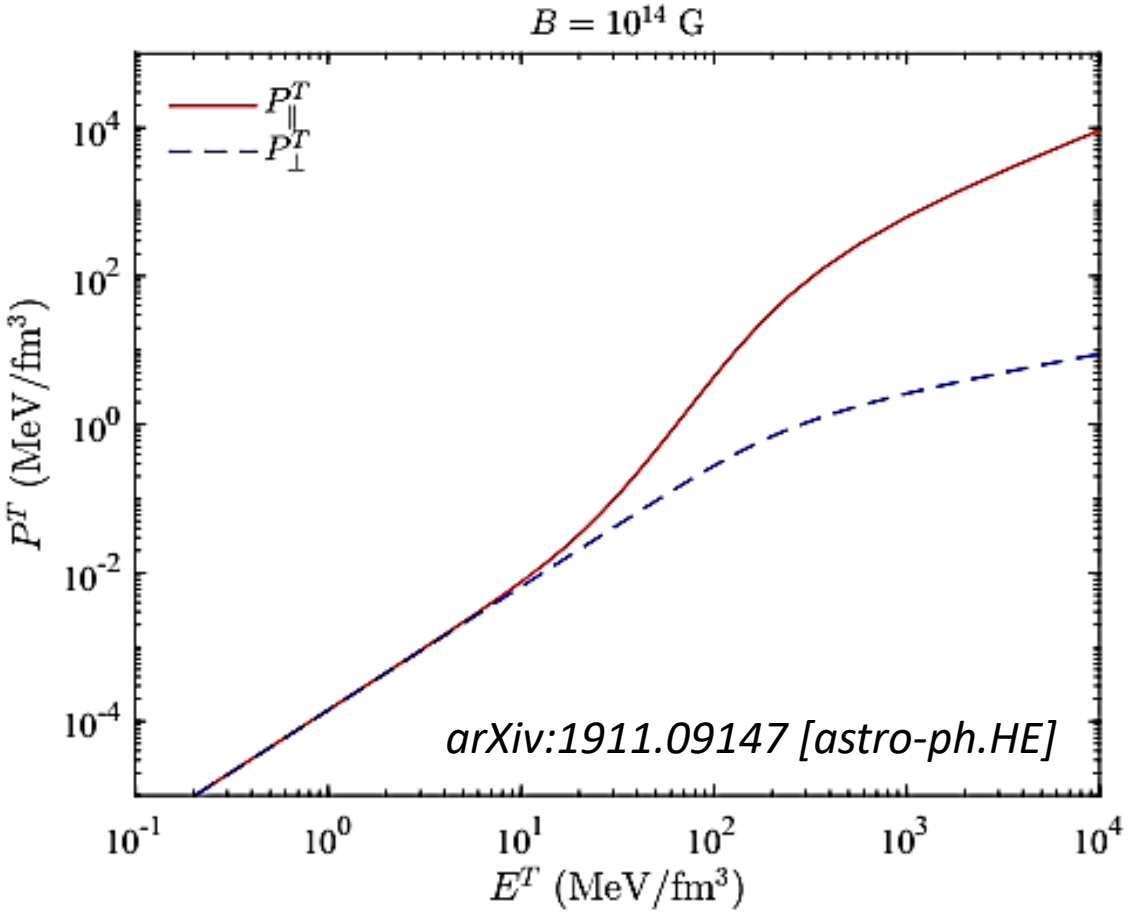
Answers and results

A1. Depending on the magnetic field and the particle density, the electron, proton, neutron, and paired neutron gases may collapse, while the gas of paired protons is always stable.

A2. The collapsed gases could overcome gravity and trigger the expulsion of matter out of the compact object.

A3. The magnetic field produced by the mixture of gases is strong enough to keep it in a collapsed configuration once they leave the star.



Furthermore:

- The difference between the parallel and perpendicular pressures of the collapsed matter reach up to three orders of magnitude, so the equations of state obtained in this framework (see the plot) are expected to describe highly elongated structures such as jets.
- The proposed mechanism could be extended to realistic matter models as long as they contain gases susceptible to suffer a transversal magnetic collapse.

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