Young Close Neutron Stars in the Gould Belt

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(Based on Popov, Turolla, Prokhorov, Colpi, Treves, astro-ph/0305599)

LIGO-G030462-00-W

The Question of Interest

Is the Gould Belt a good location to look for gravitational waves from neutron stars?

The question addressed by Popov et al.

- X-ray missions (e.g. ROSAT) have found more isolated neutron stars (INSs) in the solar neighborhood than expected based on the NS birthrate in the galactic disk. (A factor a few more are observed than predicted.)
- A recent enhanced SN rate in the Gould Belt is a possible explanation.

The Gould Belt

- The Gould Belt is a collection of nearby young star clusters.
- Popov et al., model it as a thin disk 50 - 300 pc from the Sun, tilted 18 degrees to the galactic plane.

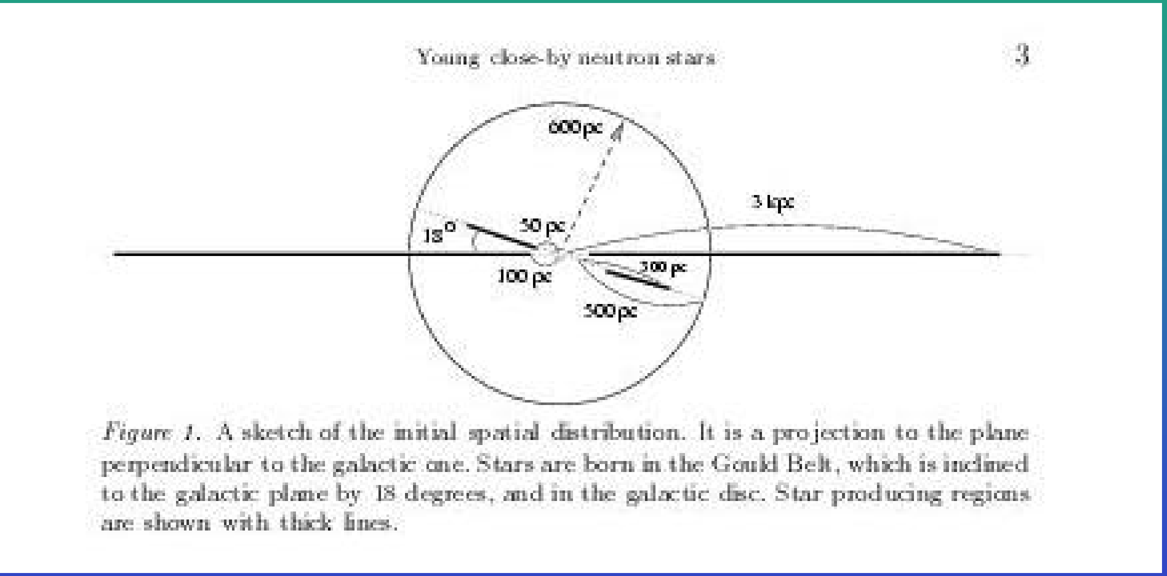

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Figure 1. A sketch of the initial spatial distribution. It is a projection to the plane perpendicular to the galactic one. Stars are born in the Gould Belt, which is inclined to the galactic plane by 18 degrees, and in the galactic disc. Star producing regions are shown with thick lines.

Popov et al., astro-ph/0305599

Popov et al., Model

- NS are formed continuously in the Gould Belt and in the galactic plane (latter included for 100 – 3000 pc from Sun).
- Formation rates are based on SN progenitor counts; the rate in Gould belts is a few times that in galactic disk.
- NS mass distribution is based on SN progenitor count in a spherical shell from 100 pc to 600 pc around the Sun. (Cooling depends strongly on mass.)
- Initial velocities (natal kicks) are drawn from Maxwellian or sum of two Maxwellian distributions.
- NS position and temperatures (based on standard cooling curves) are evolved to get spatial and x-ray flux distributions.
- 10000 NSs are evolved for 4.25 Myrs and then normalize to get expected 1000 NS within 600 pc of the Sun.

X-ray Flux Distribution

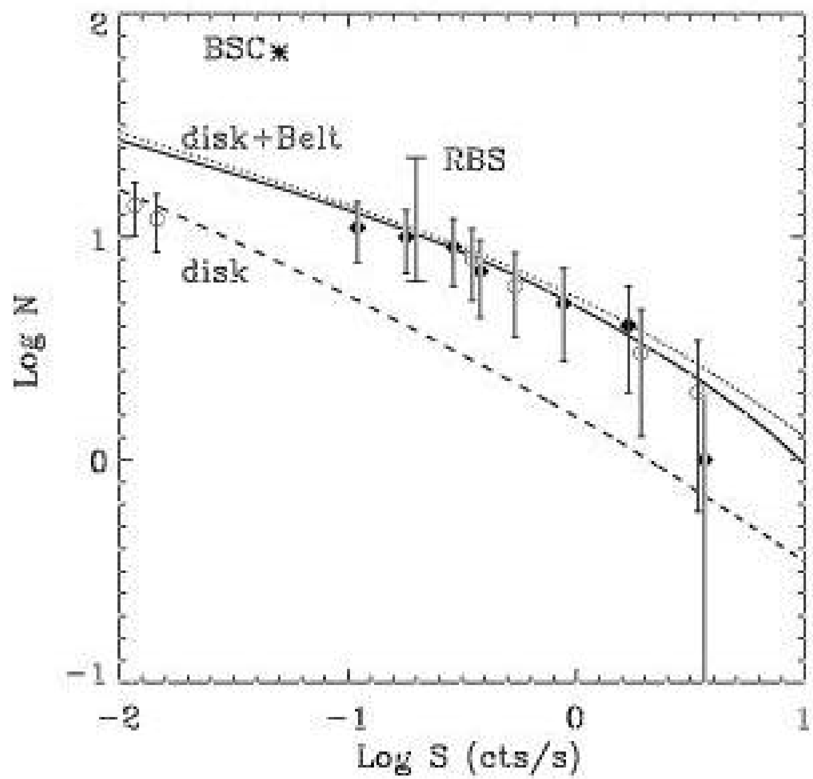


Figure 5. A "new" model (solid line: R_{Belt} = 300 pc, new mass spectrum, an "atmospheric effect", new kick velocity distribution) in comparison with older results (dotted line — disc+Belt, dashed line — only disc).

Popov et al., astro-ph/0305599

Spatial Distribution

10 Popov et al.

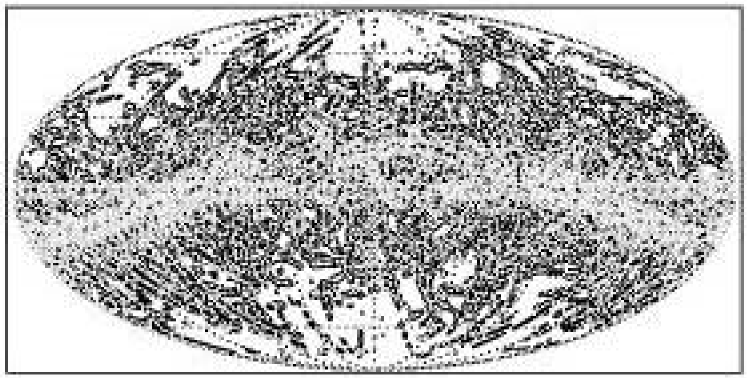


Figure 6. Projected distribution of cooling INSs in the sky in galactic coordinates. Only sources with count rate > 0.05 cts s^{-1} are accounted for. The total number of such sources is ~ 17 (see fig. 5). The plot shows contours of constant INS number density per square degree. Darker areas close to the Belt or/and to the galactic plane correspond to ~ 0.001 sources/square degree. The presence of the Belt produces a tilt in the higher projected density region which is visible in the figure.

Popov et al., astro-ph/0305599

Tania's Email to PULG

`Here is what I understood about the Gould belt. Massive stars have been forming in this region for 30-40 Myr. The supernova rate is ~75-95 SN/Myr/kpc^2 - ~3-5 times higher than the Galactic rate (see Grenier 2000) - which gives ~20 SN/Myr. The distance Earth/Gould belt is 50-400 pc. For S2 - assuming an ellipticity of 10^-6 - this gives detectable frequencies > ~100-200Hz. Even with a small magnetic field (10^12 G) and the minimal initial rotational period (0.5 ms), these frequencies are reached within ~5 10^4 yr (see attached plot: evolutionary paths for given values of B, assuming a magnetic breaking only) Then we shouldn't expect more than 1 detectable pulsar in the Gould belt (which is not 0!)`

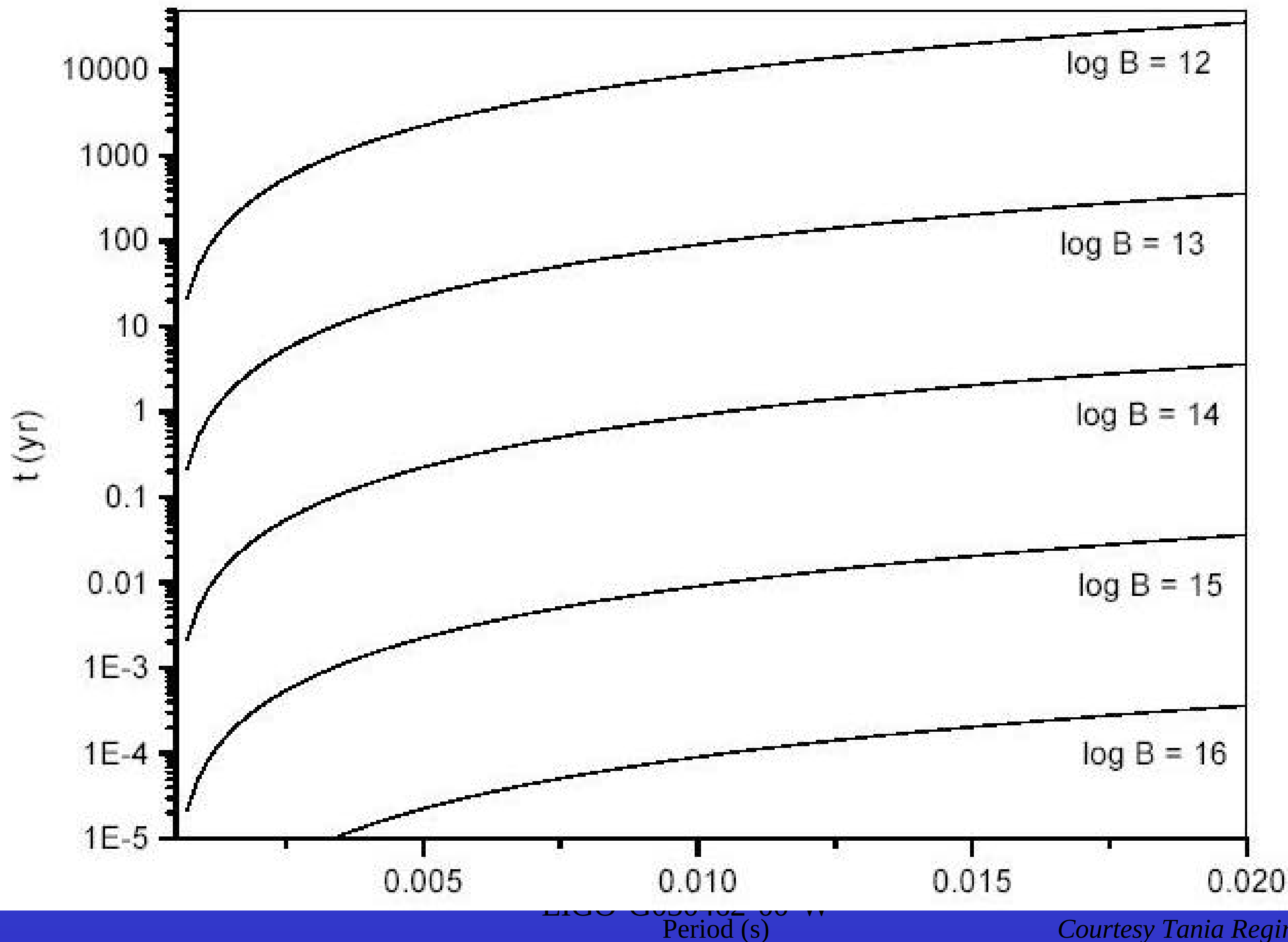
`Of course this is just probability calculations!`

[I assume this comes from:

75-95 SN/Myr/kpc^2 * 5 x 10^4 yr * (1 Myr/10^6 yr) * p * (50-400 pc)^2 * (1 kpc^2/10^6 pc^2) £ 1.

However, what if we assumed the spindown was due to GWs only?]

Spin Down vs. Magnetic Field



Courtesy Tania Regimbau