Kicking Pulsars Hard[1]

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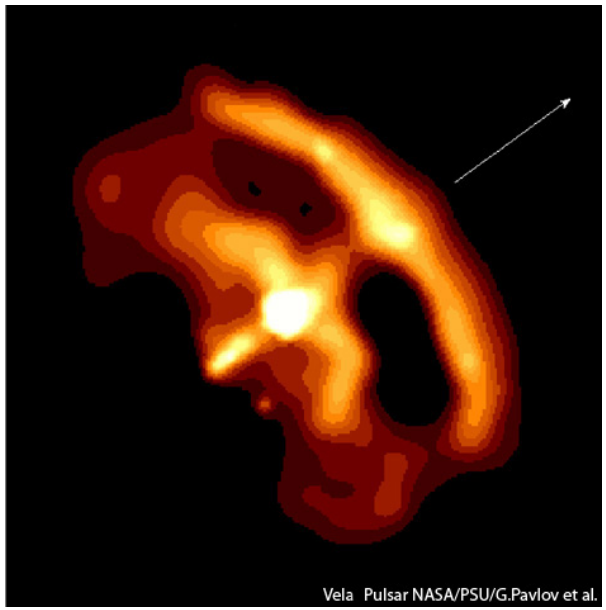
[1] Charbonneau, Hoffman and Heyl, *Large Pulsar Kicks from Topological Currents.* [arXiv:0912.3822] (2009)

Pulsars have large kicks that we can't explain

Pulsars move much faster than their progenitors, they have been kicked.

- The typical pulsar velocity is 400 km/s
- 15% of pulsars have velocities over 1000 km/s.

Large kicks do not have a suitable explanation.



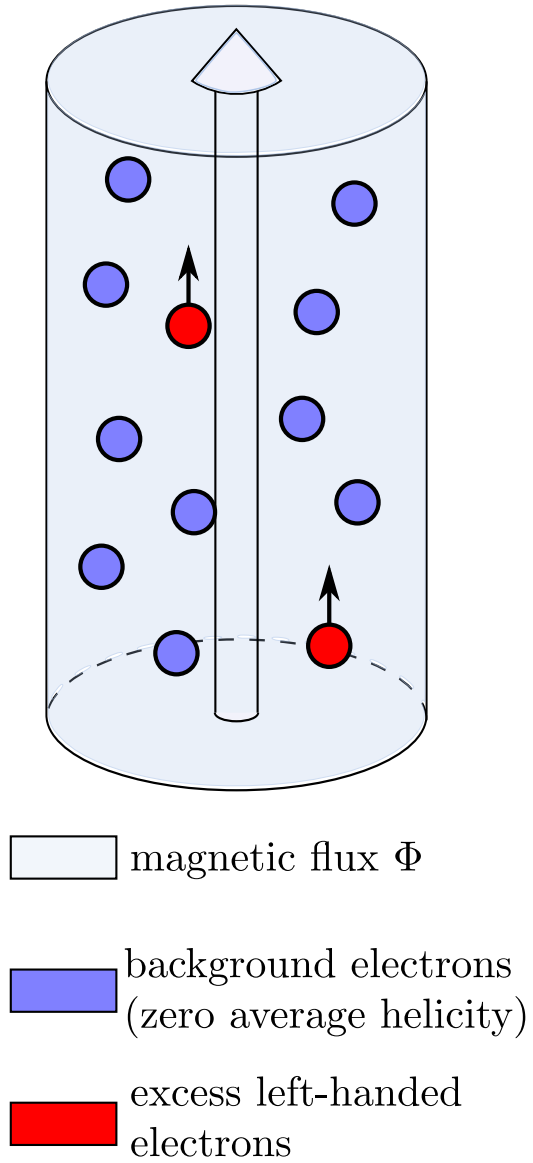
Topological Vector Currents[2]

Topological vector currents carry electrons along magnetic flux lines in dense matter.

The currents appear in dense stars because

- the electrons have large Fermi momentum.
- the lowest Landau level only admits spin down electrons.
- the Urca processes violate parity,

$$n \to p + e^- + \bar{\nu}_e$$
$$p + e^- \to n + \nu_e$$



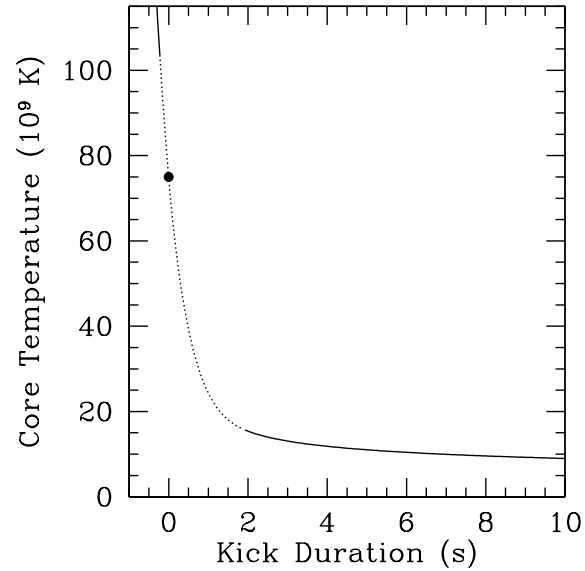
[2] Charbonneau and Zhitnitsky [arXiv:0903.4450] (2009)

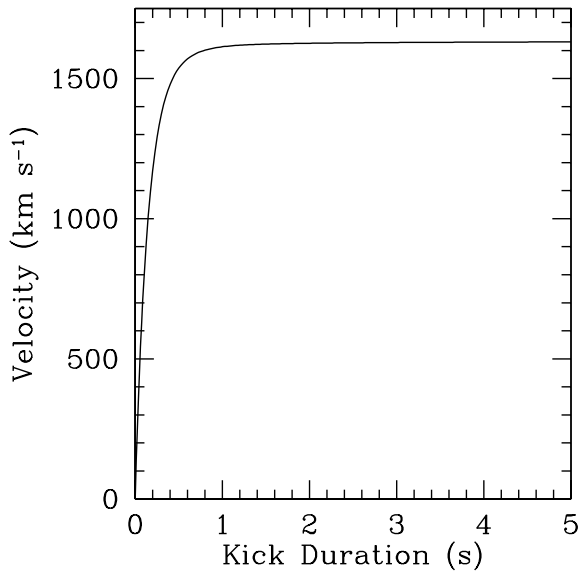
Kicks from Topological Currents

1. Electrons transfer momentum.
   - electron rocket!
   - bremsstrahlung.
   - quark stars only.

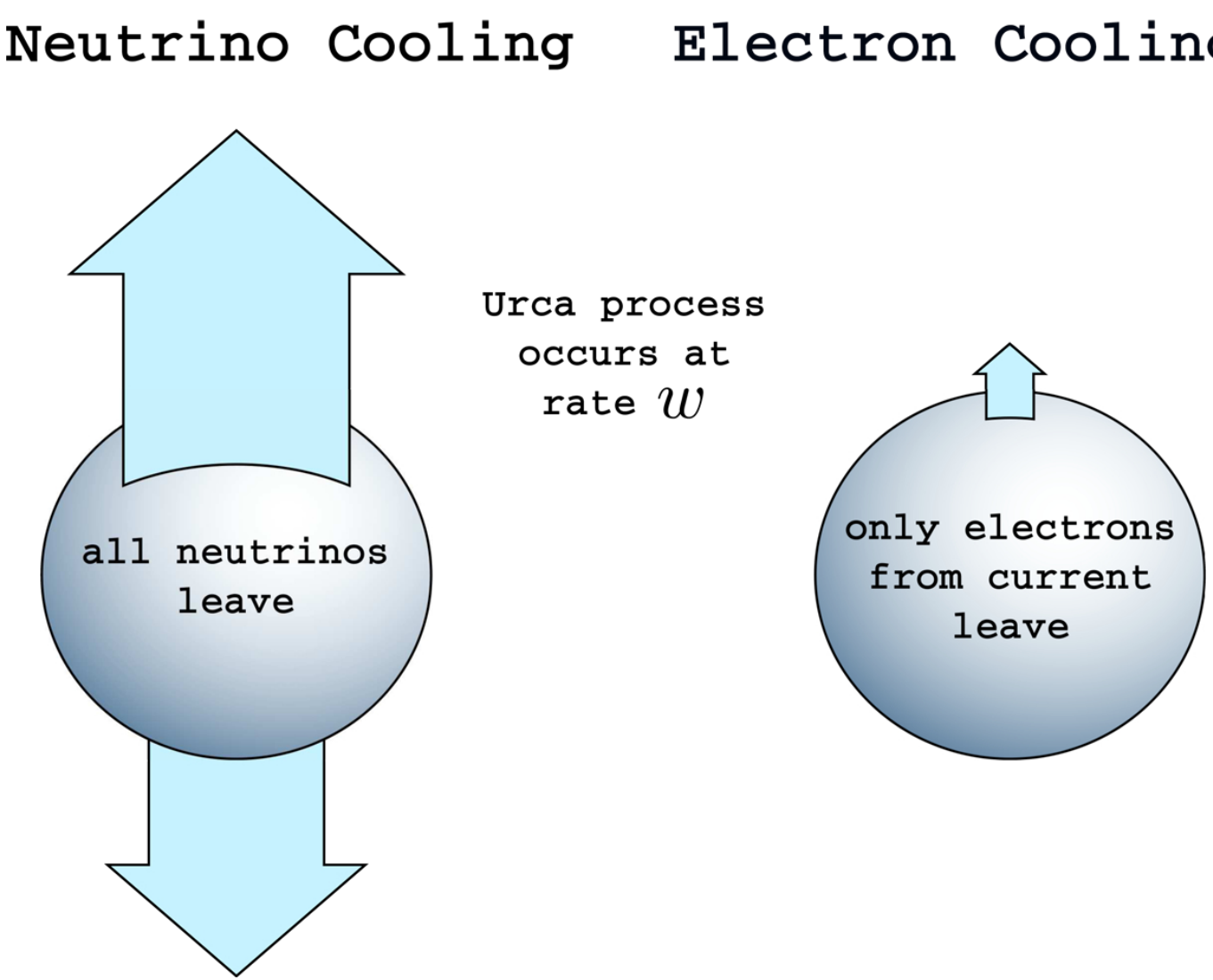
2. Current is sensitive to Temperature, need a realistic cooling curve.
   - Haensel et al. (1991)
   - Page & Usov (2002)

3. Mechanism generates large kicks > 1000 km/s.





Doesn't the current affect the cooling?



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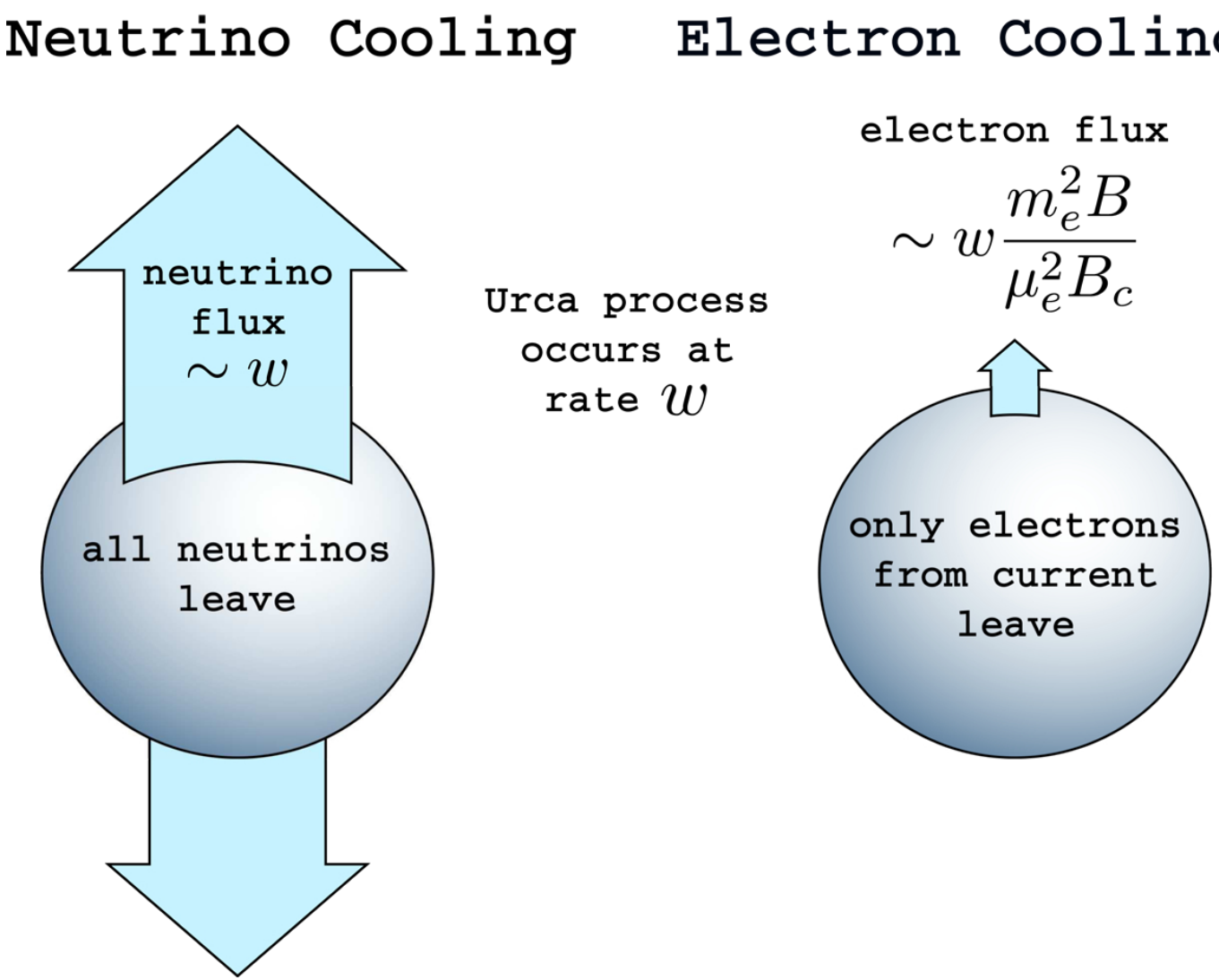

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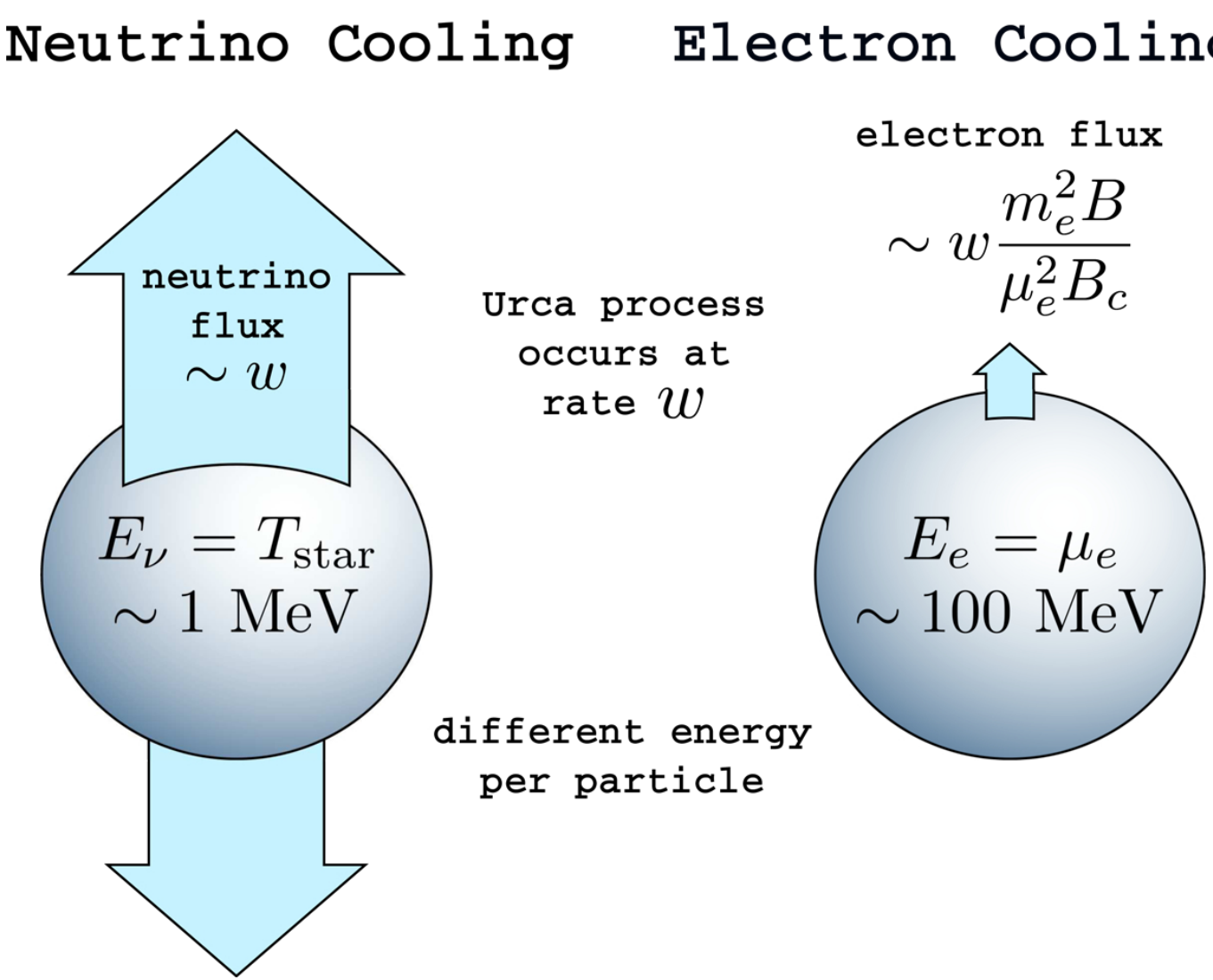

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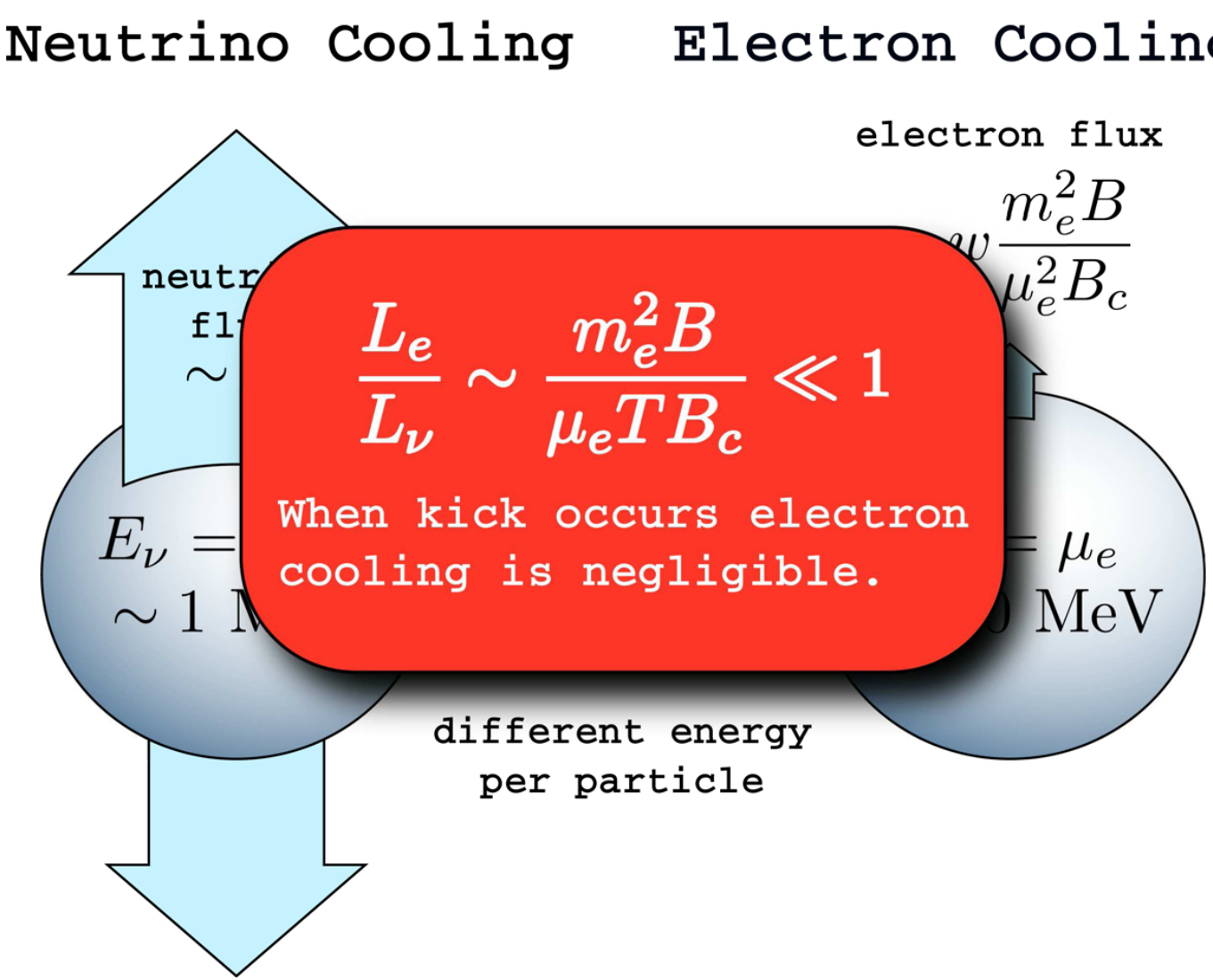
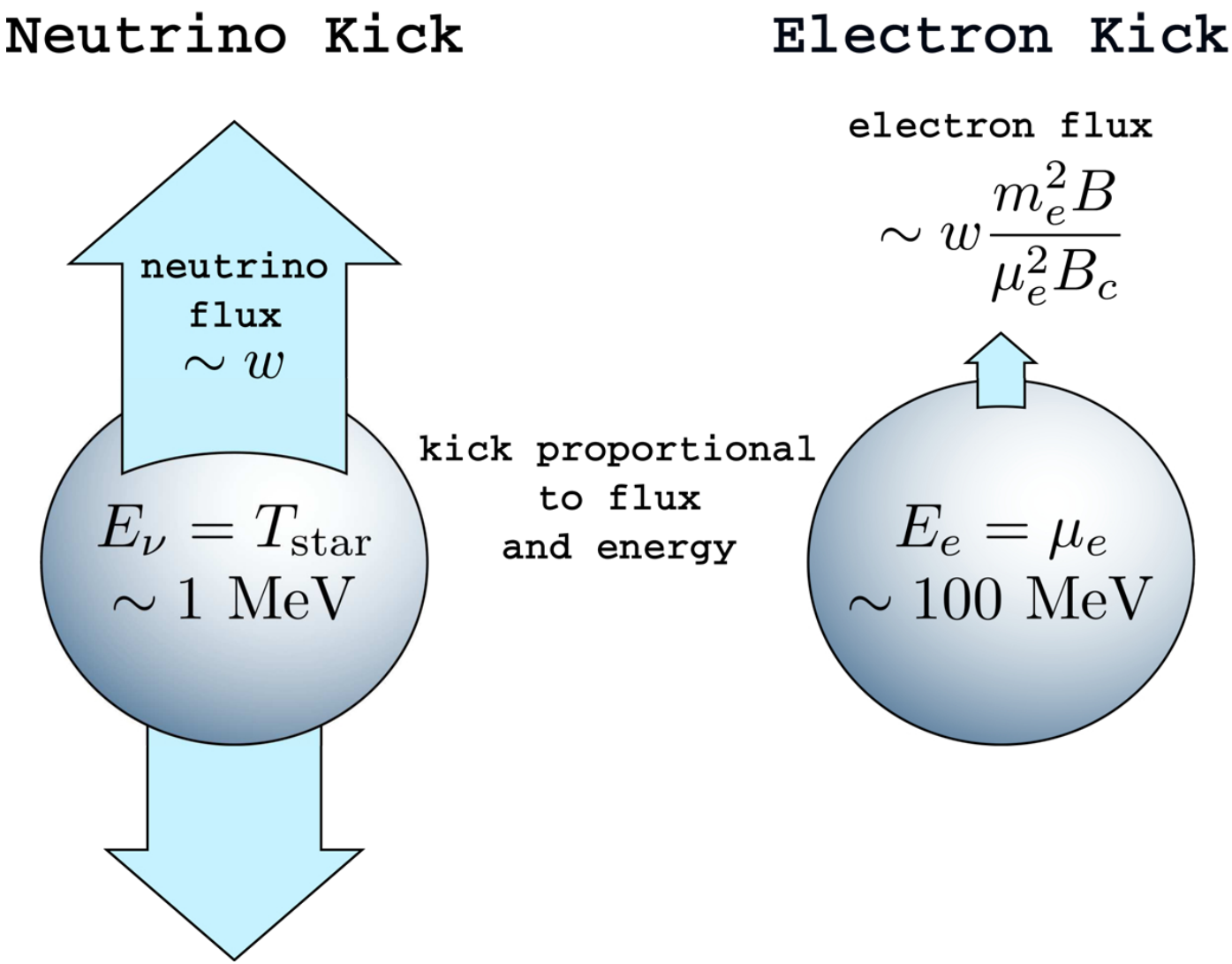


So why is the electron kick bigger?



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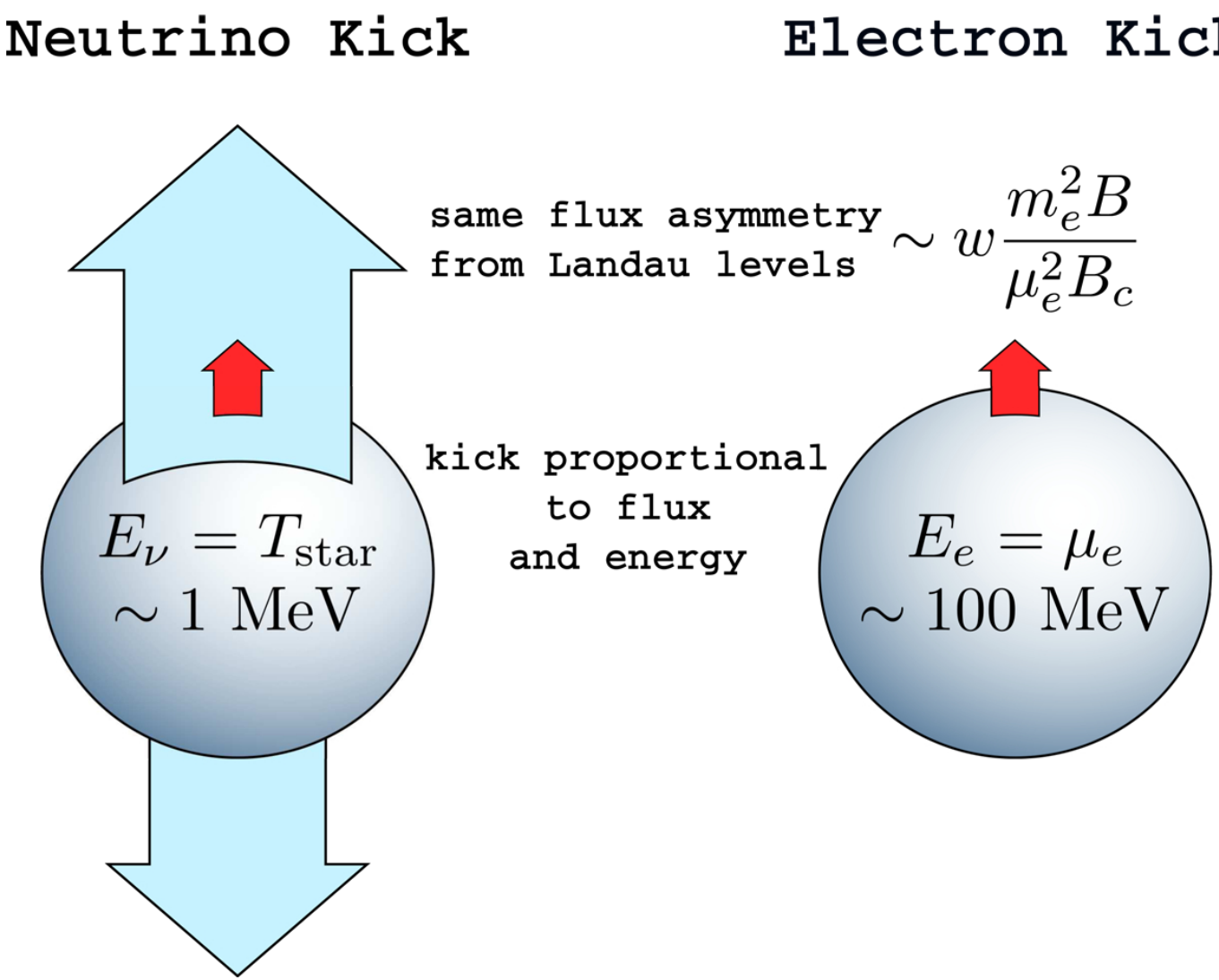

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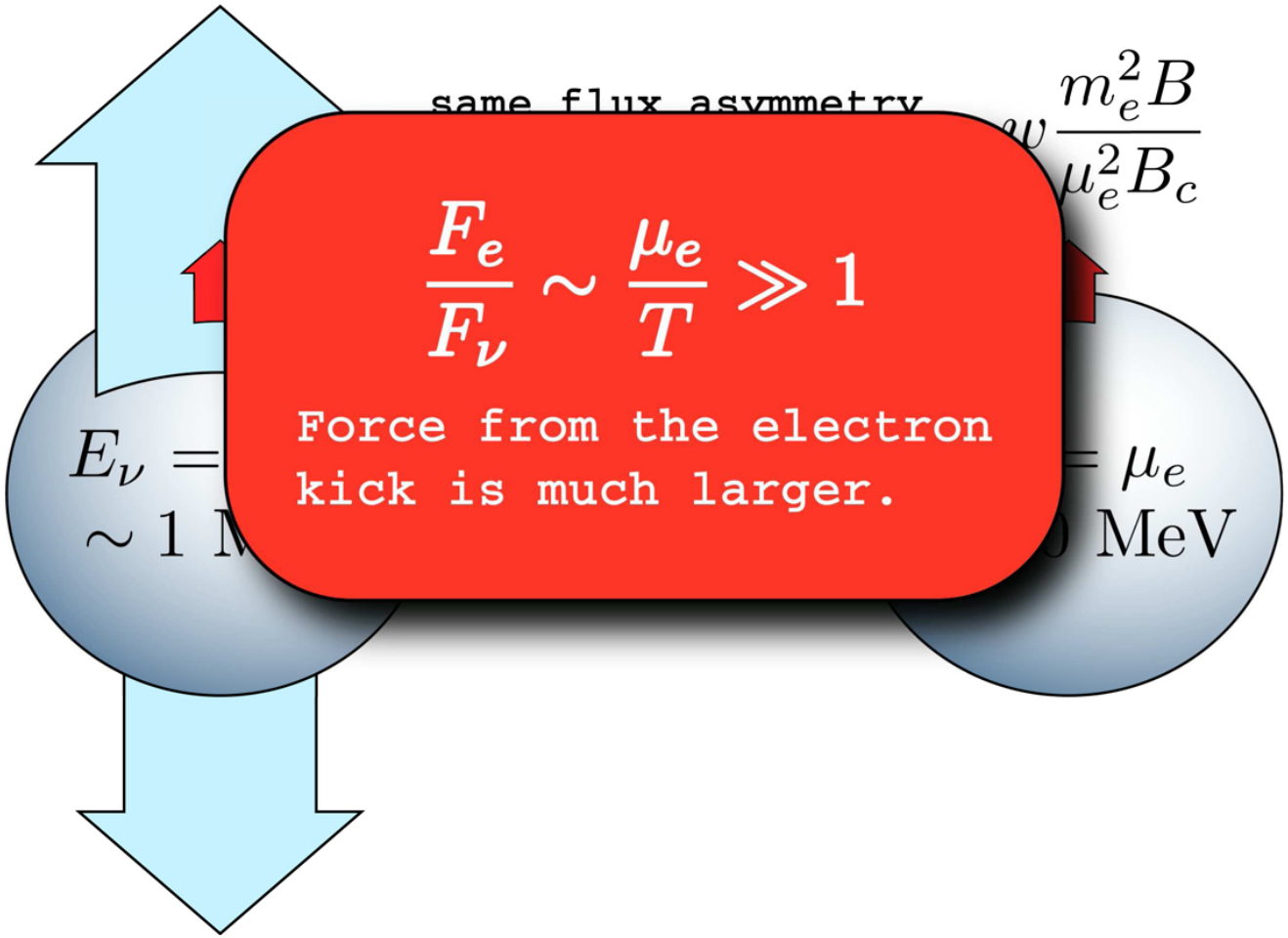

Conclusion

Topological currents can generate large kicks.

1. We use a realistic cooling model to estimate the kick.
2. Current dominates cooling later in life.
3. Leads to the conjecture that pulsars with large kicks are quark stars.