A wind nebula is a bubble of relativistically hot particles containing the shocked relativistic MHD wind from the central neutron star. It serves as an excellent calorimeter that tracks the energy injection and adiabatic cooling history of the system while it expands into the unbound SN ejecta. The magnetar injects a rotationally powered wind into its MWN with a power

$$L_{\text{MWN}} = L_{0} \left( \frac{1}{t} \right)^{\alpha}$$

where \(L_{0}\) is the initial kinetic energy, \(t_{0}\) is the initial spin-down time, and \(\alpha\) is a power-law index. We consider two cases: (i) \(t_{0} = 1\) ms, \(E_{0} > E_{\text{SN}}\) the magnetar injects more energy than the kinetic energy of the expanding SN ejecta, and the dynamical evolution of the SNR+MWN system is significantly different from the other cases. (ii) \(t_{0} = 10\) ms, \(E_{0} < E_{\text{SN}}\). In both cases, the initial spin-down time is significantly shorter than the dynamical timescale of the SNR expansion.

**Figures**

- **Top** Dynamical evolution of MWN and SNR radius \(R_{\text{SNR}}(t) = \frac{R_{\text{SNR}}(0)}{t^{\beta}}\) in a uniform density ISM and assuming initial surface dipole magnetic field \(B_{0}\).
- **Bottom** Minimun age of the MWN for it to have expanded after reverse-shock crushing to the size of the observed X-ray nebula, shown here for a range of \(B_{0}\) and the parameter \(\chi\), which encodes oscillations in the superradiation radius due to reverberations. \(R_{\text{MWN}}(t) = \frac{R_{\text{MWN}}(0)}{t^{\beta}}\).

Other parameters are: \(\alpha = 3\), \(\Delta t_{\text{MWN}} = 10^{-5} \text{ Myr}\).

**Conclusions**

- The wind nebula around the magnetar Swift J1834.9–0846 is instrumental in understanding the properties of the magnetar's outflows. Our analysis yielded the following conclusions:
  - The local nebula cannot be powered by the quiescent MHD wind alone, and needs an extra source of energy—most likely energy injection by the super-Eddington episodic outbursts.
  - The geometrical factors for the decay of the magnetar's dipole field alone, and is most likely the death of its much stronger internal magnetic field.
  - The GeV/TeV emission cannot be of IC origin and is more likely to come from hadronic emission of CR protons interacting with target protons in the nearby GC.