Questions: Afterglow

August 17, 2018

Physics constants and astrophysical units.

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\begin{array}{ll}
G & 6.67384 \times 10^{-8}\ \mathrm{cm}^3\ \mathrm{g}^{-1}\mathrm{s}^{-2} \\
c & 2.99792458 \times 10^{10}\ \mathrm{cm\ s}^{-1} \\
h & 6.626070040 \times 10^{-27}\ \mathrm{erg\ s} \\
\hbar & 1.054571628 \times 10^{-27}\ \mathrm{erg\ s} \\
m_p & 1.6726217 \times 10^{-24}\ \mathrm{g} \\
m_u & 1.6605389 \times 10^{-24}\ \mathrm{g} \\
m_e & 9.10938291 \times 10^{-28}\ \mathrm{g} \\
e & 4.80320425 \times 10^{-10}\ \mathrm{erg}^{1/2}\mathrm{cm}^{1/2} \\
\alpha = \dfrac{e^2}{\hbar c} & \dfrac{1}{137.035999139} \\
\sigma_{\mathrm{T}} = \dfrac{8\pi e^4}{3m_e^2 c^4} & 6.6524574 \times 10^{-25}\ \mathrm{cm}^2 \\
a_{\mathrm{B}} = \dfrac{\hbar}{m_e c\alpha} & 5.2917721067 \times 10^{-9}\ \mathrm{cm} \\
k_{\mathrm{B}} & 1.3806488 \times 10^{-16}\ \mathrm{erg\ K}^{-1} \\
\sigma_{\mathrm{SB}} & 5.6704 \times 10^{-5}\ \mathrm{erg\ cm}^{-2}\mathrm{s}^{-1}\mathrm{K}^{-4} \\
a & 7.5657 \times 10^{-15}\ \mathrm{erg\ cm}^{-3}\mathrm{K}^{-4} \\
G_F/(\hbar c)^3 & 1.1663787 \times 10^{-5}\ \mathrm{GeV}^{-2} \\
M_\odot & 1.9884 \times 10^{33}\ \mathrm{g} \\
GM_\odot & 1.32712440018 \times 10^{26}\ \mathrm{cm}^3\mathrm{s}^{-2} \\
R_\odot & 6.955 \times 10^{10}\ \mathrm{cm} \\
L_\odot & 3.828 \times 10^{33}\ \mathrm{erg/s} \\
\mathrm{Jy} & 10^{-23}\ \mathrm{erg\ s}^{-1}\mathrm{cm}^{-2}\mathrm{Hz}^{-1} \\
\mathrm{AU} & 1.495978707 \times 10^{13}\ \mathrm{cm} \\
\mathrm{pc} & 3.08568 \times 10^{18}\ \mathrm{cm}
\end{array}
\tag{1}
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Superluminal motion

(1) Consider a particle moving at velocity β and we observe it from θ_v with respect to the velocity vector. Show the apparent velocity is

$$\beta_{\rm app}(\theta_v) = \frac{\beta \sin\theta_v}{1-\beta\cos\theta_v}. \tag{2}$$

(2) Derive the maximum apparent velocity for a given β.

(3) The jet in GW170817 exhibits a superluminal motion of ≈ 4 in units of c around 75-230 day. Discuss the Lorentz factor of the jet and viewing angle to the jet.

(4) A relativistic blast wave colliding with the interstellar medium of $n[\mathrm{cm}^{-3}]$ evolves as

$$\Gamma(t) = \left(\frac{17E_{\rm iso,K}}{1024\pi n m_p c^5 t^3}\right)^{1/8}, \tag{3}$$

where t is the observer time, $E_{\rm iso,K}$ is the isotropic-equivalent kinetic energy of the blast wave. Calculate $E_{\rm iso,K}/n$ using the Lorentz factor obtained in problem (3).

Hubble constant

(5) Download the posterior sample of H_0 and $\cos\theta_v$ from a LVC wabpage https://dcc.ligo.org/public/0145/P1700296/005/Figure2.csv

(6) Plot the posterior distribution in a H_0-$\cos\theta_v$ plane.

(7) Try to impose a constraint $\theta_v < 0.4$ rad and plot the new posterior distribution.