Unraveling parameter degeneracy in GRB data analysis

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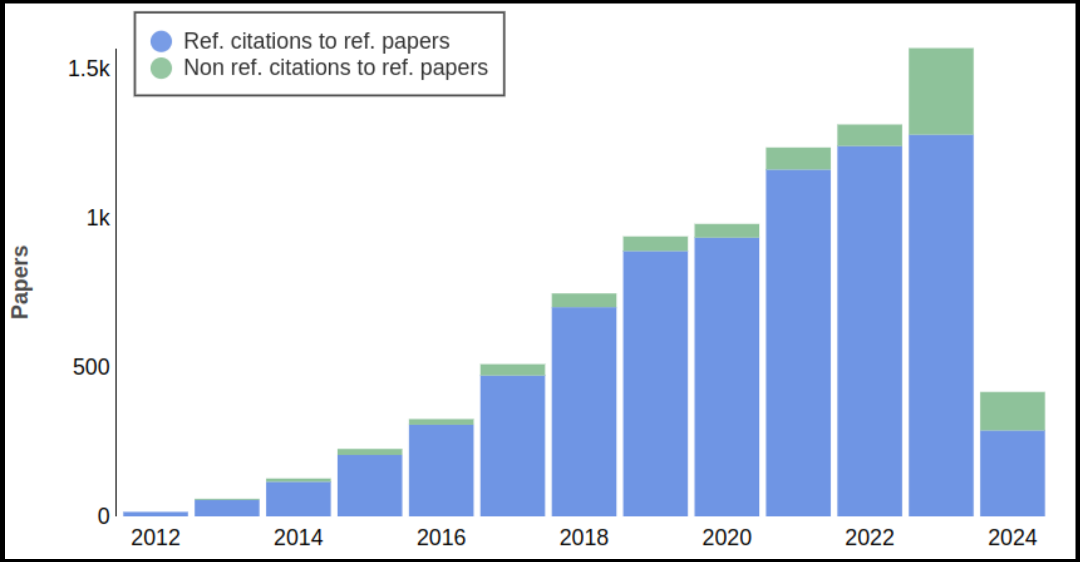
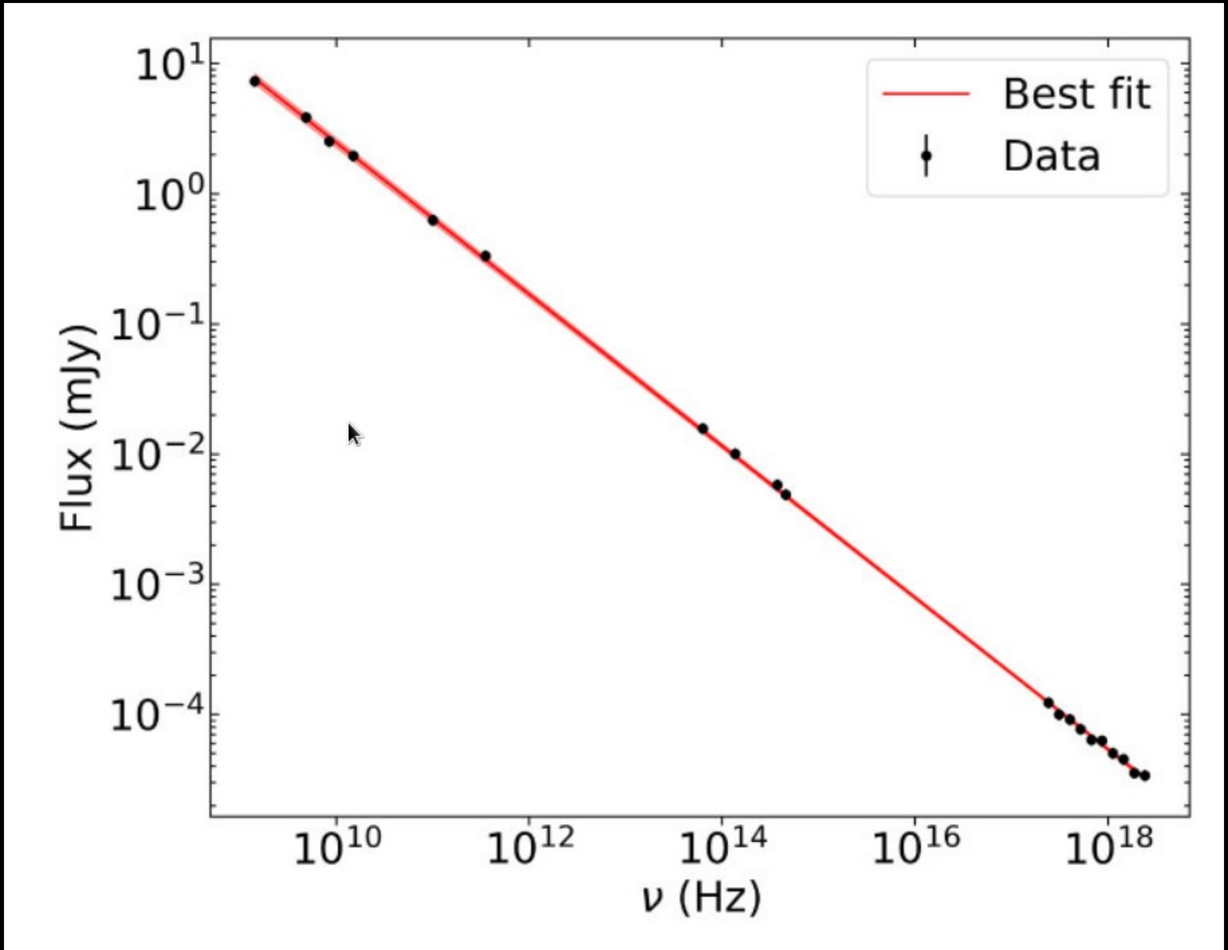
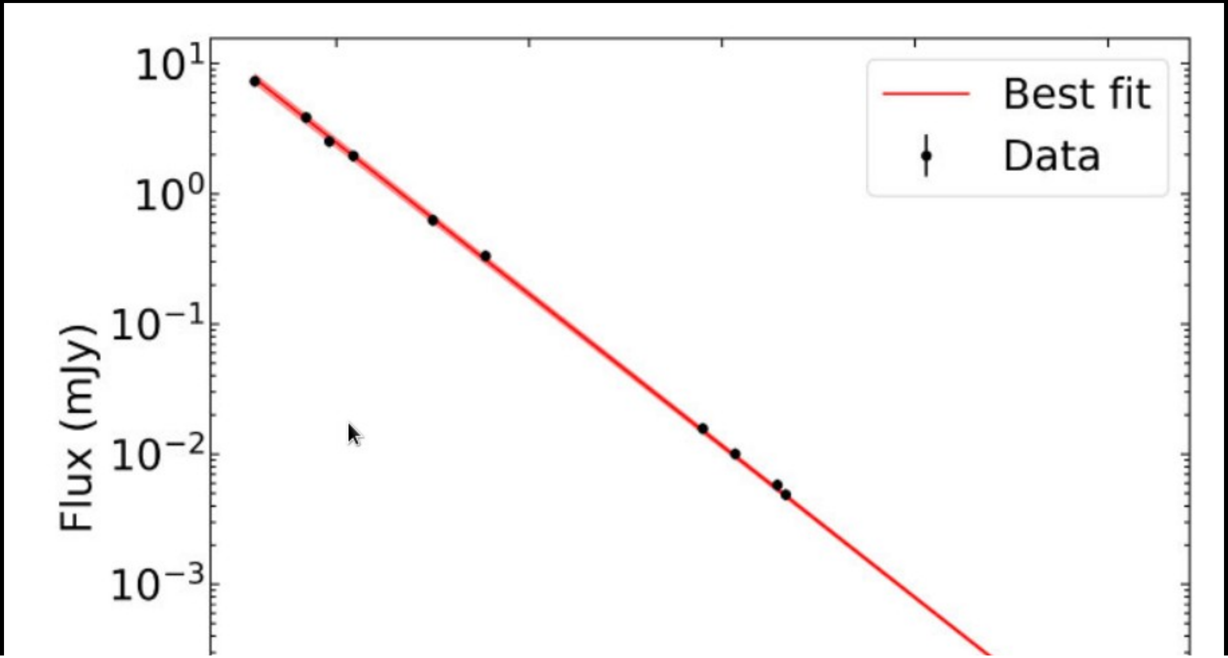
1. MCMC



Foreman-Mackey et al. (2013)

2. GRBs are often (always?) degenerate!

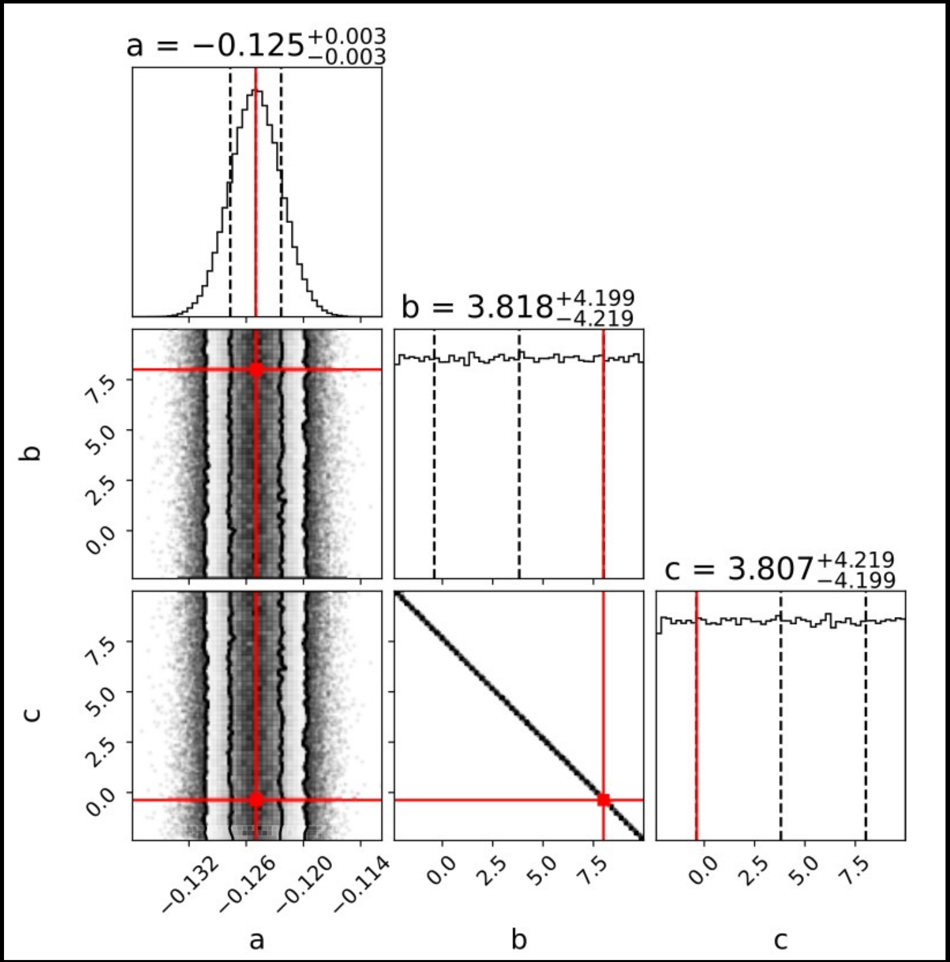

Best fit
Data
Flux (mJy)
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{10}
10^{12}
10^{14}
10^{16}
10^{18}
ν (Hz)



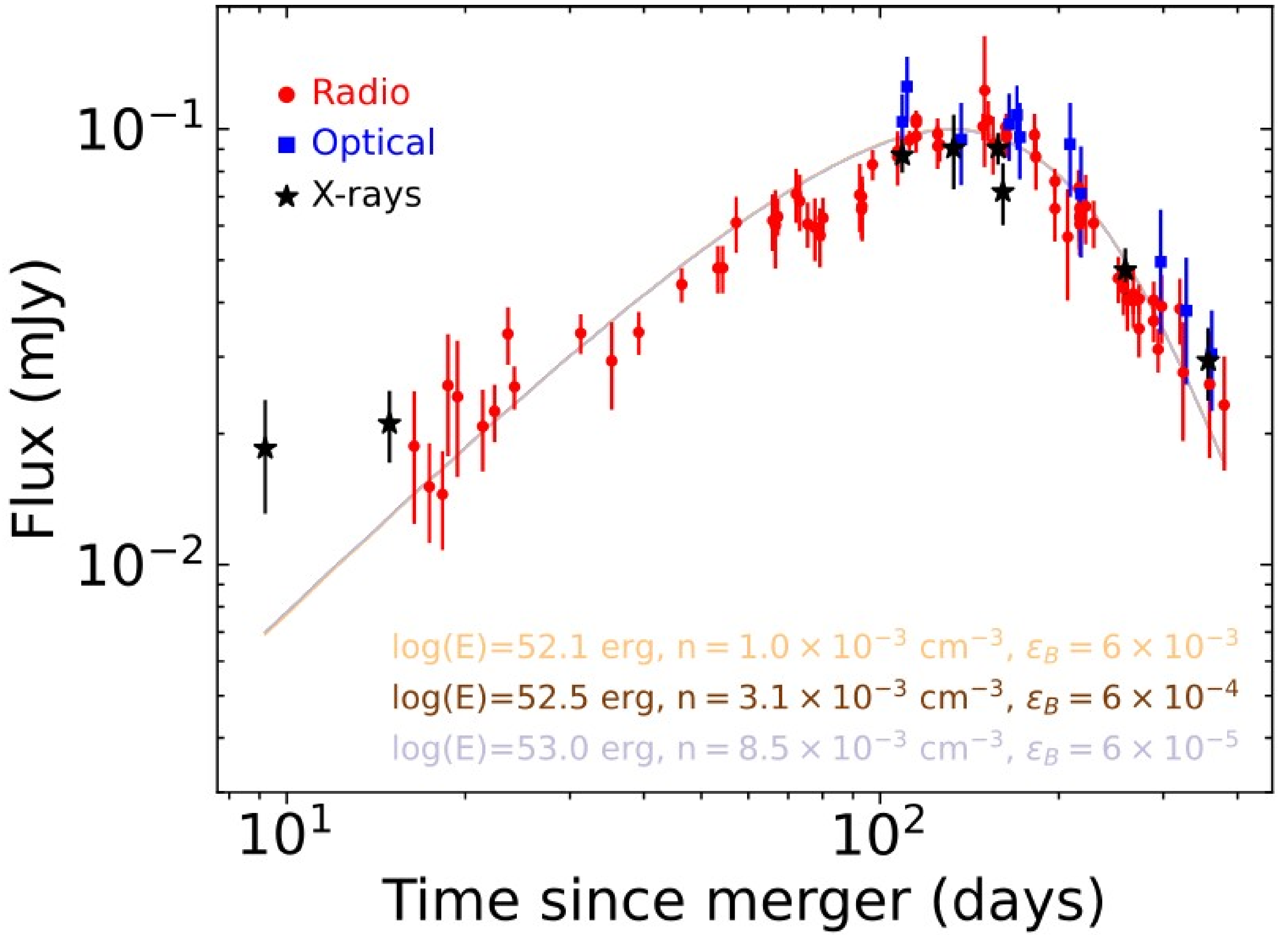
$$F(\nu,t) = \alpha n^{1/2} E_0^{(3+p)/4} \epsilon_e^{p-1} \epsilon_B^{\frac{p+1}{4}} \nu^{\frac{1-p}{2}} t_{\rm obs}^{3(1-p)/4}$$

Granot & Sari (2002)

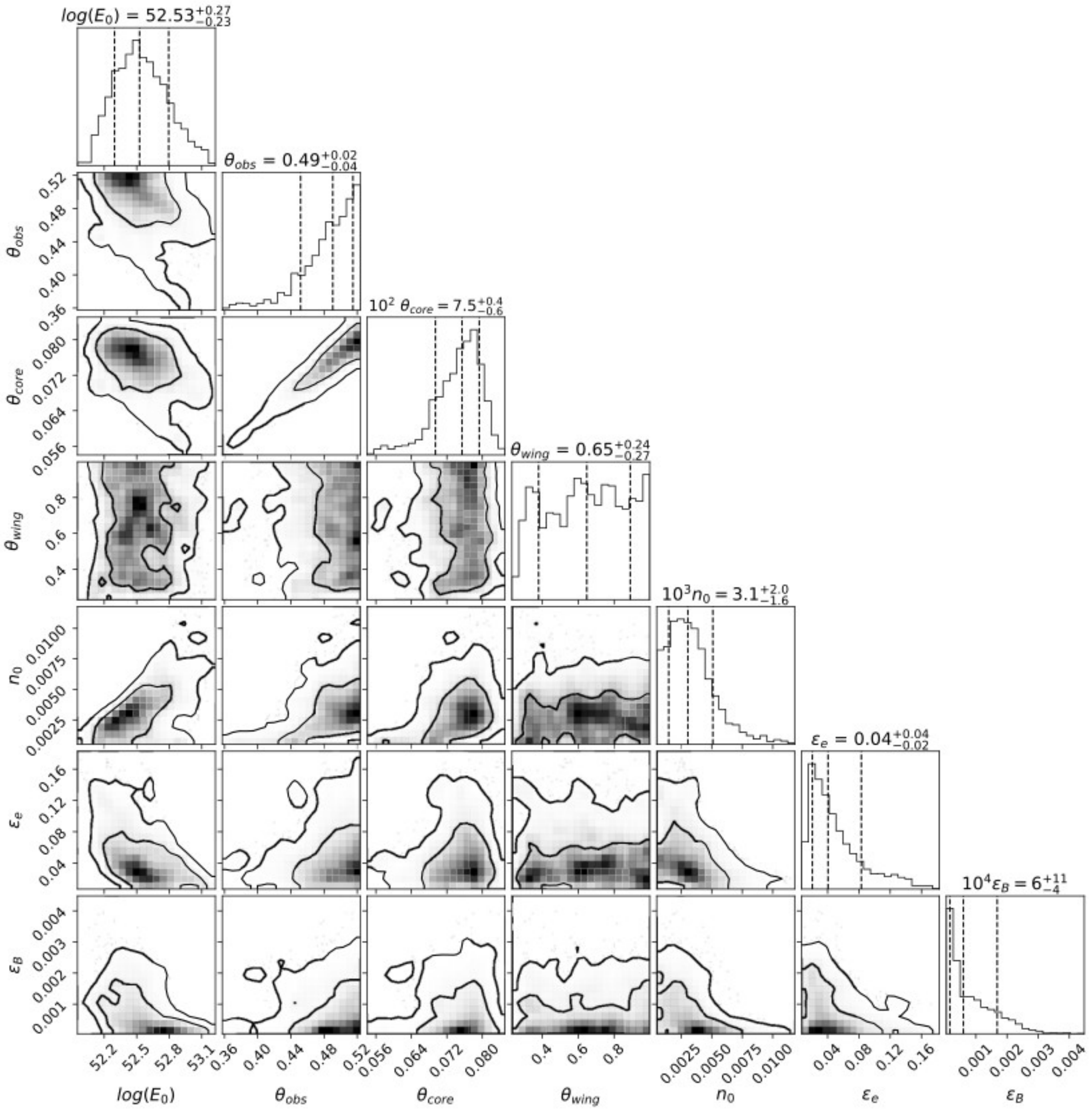
→ What happens when MCMC is applied to a degenerate problem?


a = −0.125 +0.003 −0.003
b = 3.818 +4.199 −4.219
c = 3.807 +4.219 −4.199
−0.132
−0.126
−0.120
−0.114
0.0
2.5
5.0
7.5
a
b
c

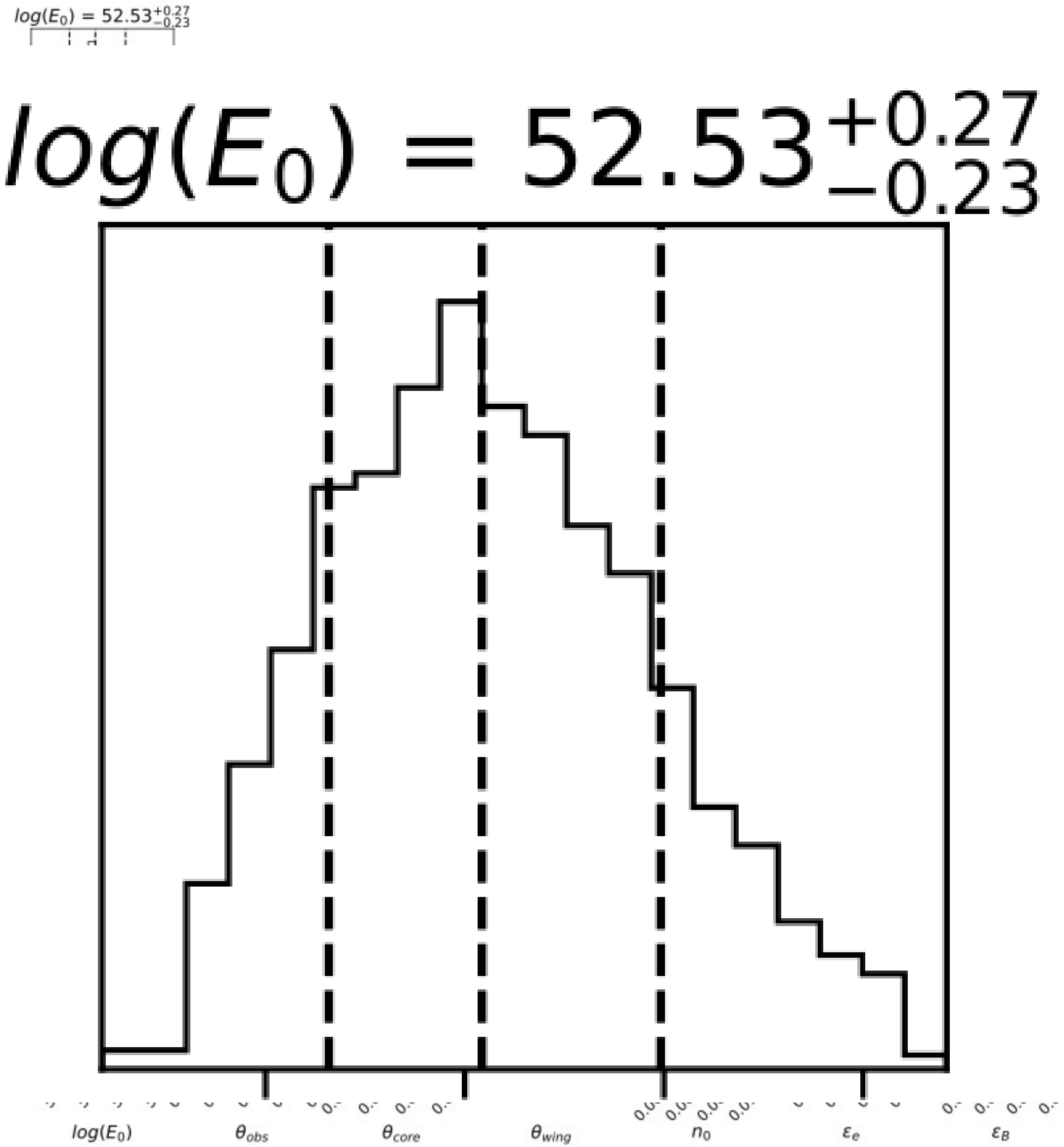
$$g(x) = ax + (b + c)$$

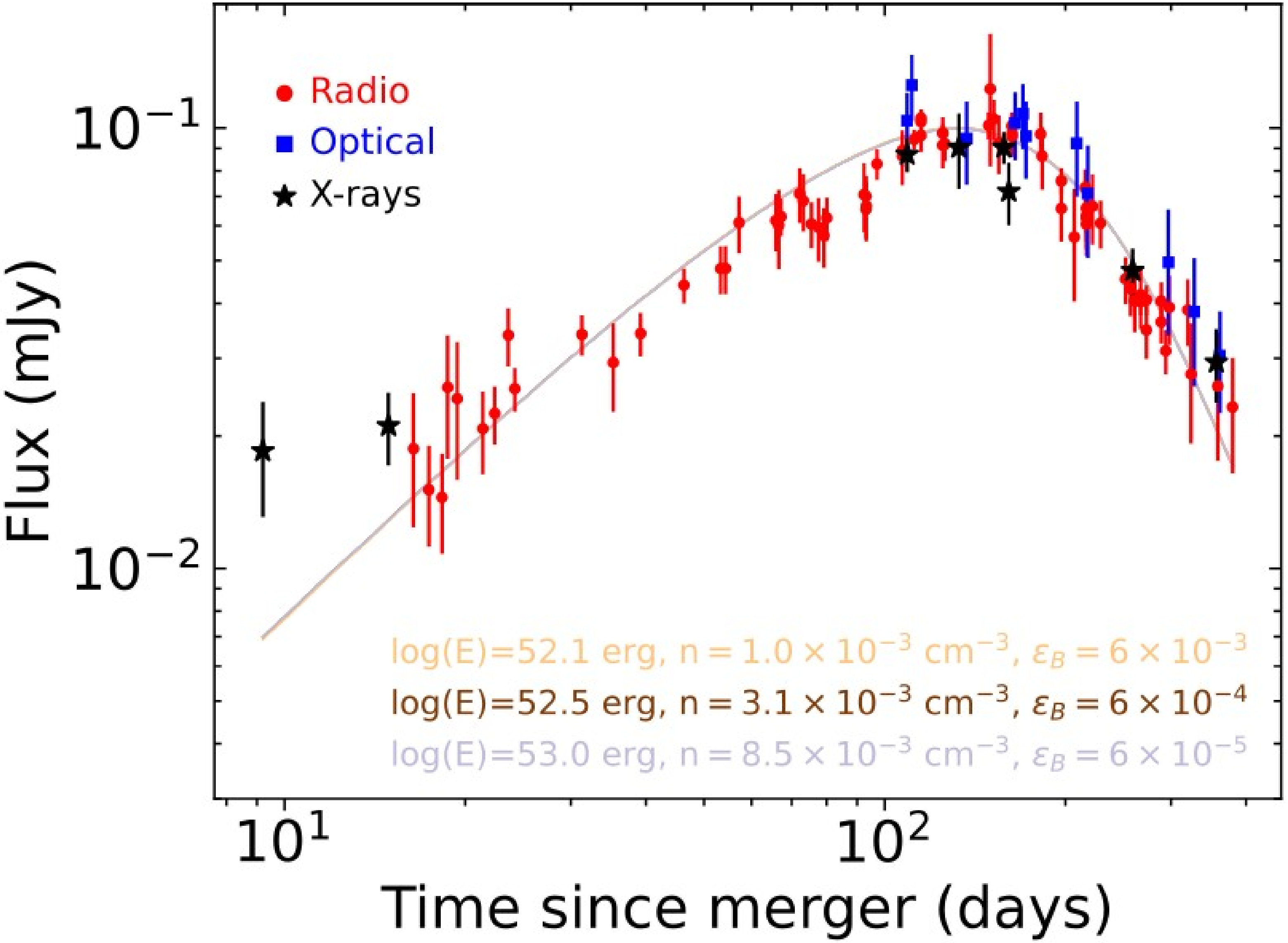


Radio
Optical
X-rays
10^{-1}
10^{-2}
Flux (mJy)
10^{1}
10^{2}
Time since merger (days)
log(E)=52.1 erg, $n = 1.0 \times 10^{-3}$ cm^{-3}, $\varepsilon_B = 6 \times 10^{-3}$
log(E)=52.5 erg, $n = 3.1 \times 10^{-3}$ cm^{-3}, $\varepsilon_B = 6 \times 10^{-4}$
log(E)=53.0 erg, $n = 8.5 \times 10^{-3}$ cm^{-3}, $\varepsilon_B = 6 \times 10^{-5}$



$log(E_0) = 52.53^{+0.27}_{-0.23}$
$\theta_{obs} = 0.49^{+0.02}_{-0.04}$
$10^2\ \theta_{core} = 7.5^{+0.4}_{-0.6}$
$\theta_{wing} = 0.65^{+0.24}_{-0.27}$
$10^3 n_0 = 3.1^{+2.0}_{-1.6}$
$\epsilon_e = 0.04^{+0.04}_{-0.02}$
$10^4 \epsilon_B = 6^{+11}_{-4}$
$log(E_0)$
θ_{obs}
θ_{core}
θ_{wing}
n_0
ϵ_e
ϵ_B


$log(E_0) = 52.53^{+0.27}_{-0.23}$
$log(E_0)$
θ_{obs}
θ_{core}
θ_{wing}
n_0
ϵ_e
ϵ_B



Radio
Optical
X-rays
log(E)=52.1 erg, n = 1.0 × 10^−3 cm^−3, ε_B = 6 × 10^−3
log(E)=52.5 erg, n = 3.1 × 10^−3 cm^−3, ε_B = 6 × 10^−4
log(E)=53.0 erg, n = 8.5 × 10^−3 cm^−3, ε_B = 6 × 10^−5
Flux (mJy)
10^−1
10^−2
10^1
10^2
Time since merger (days)

Conclusions:

The parameter degeneracy can go unnoticed when using the MCMC method

It is important to clearly identify the degeneracy present in GRB afterglows models when doing fits

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