Exercises Stellar Transients

Useful numbers

These numbers may be useful when solving the exercises.

Solar mass	$M_\odot$	$1.99 \cdot 10^{33}\,\mathrm{g}$
Solar luminosity	$L_\odot$	$3.85 \cdot 10^{33}\,\mathrm{erg\,s^{-1}}$
Parsec	pc	$3.086 \cdot 10^{18}\,\mathrm{cm}$
Speed of light	c	$2.998 \cdot 10^{10}\,\mathrm{cm\,s^{-1}}$
Gravitational constant	G	$6.673 \cdot 10^{-8}\,\mathrm{erg\,cm\,g^{-2}}$
Mass of proton	m_p	$1.66 \cdot 10^{-24}\,\mathrm{g}$
Energy	1 eV	$1.602 \cdot 10^{-12}\,\mathrm{erg}$
	1 erg	10^{-7} Joule

Exercise 15: Novae vs. X-ray bursts

Argue that in both novae and X-ray bursts the released energy through nuclear burning per gramme of burnt matter is of the same order. Estimate this quantity, and use it to explain why nova explosions eject most of the accreted matter and X-ray bursts do not.

Exercise 10: The InterPlanetary Network

Arcminute localizations of GRBs were already performed in the early 1970s with the network of Vela satellites and space probes traveling at similar or slightly larger distances from earth which happened to harbor a gamma-ray detector (i.e., the IMP, OSO, SAS series). Dedicated GRB detectors were first launched in late 1970s on probes like the Veneras and PVO to Venus, forming the so-called the InterPlanetary Network for GRB localizations (IPN). The resulting positional accuracies was of order arcminutes.

a. Can you think of reasons why those localizations never resulted in optical identifications?

The method of localization is based on the differences in travel time from the GRB to the various space probes.

b. Apart from the statistical quality of the data, which other parameters determine the accuracy of the localization?

c. The geometry of the region on the sky with two active space probes in the network is a small circle with a half opening angle α and a width $\Delta\alpha$. Can you indicate how $\Delta\alpha$ depends on mutual probe distance, instrument time resolution and α?

d. If the probe distance is 8 light minutes and the time resolution 1 second, what is the width of annulus if α is 45°? What if $\alpha = 0$?

e. How many space probes are needed to pin down the GRB location completely?

Exercise 11: V/Vmax as a measure of GRB uniformity

In class we discussed the GRB logN-logP distribution which tests the uniformity of GRBs as a function of distance. This is a somewhat cumbersome diagnostic because one needs to assess the instrumental calibration. Maarten Schmidt introduced an alternative which he previously applied to quasars in the late 1960s: V/Vmax. V/Vmax is is the volume encompassed by the GRB divided by the maximum volume visible to the instrument at the time of the GRB (remember that the latter may change because of changing detection thresholds due to changing background levels).

a. If GRBs are uniformly distributed in space, what value would be expected for the average of V/Vmax?

b. If the actual <V/Vmax> is smaller than that, what does that mean?

c. Why is V/Vmax easier to use than logN-logP?