Exercise 1. Find the value of Newton constant

$$G_N = 6.67\times10^{-8}\frac{\mathrm{cm}^3}{\mathrm{g\,s}^2}$$

in Natural system of units. Express in powers of eV, s, or cm.

Exercise 2. Consider a black hole of mass M with gravitational radius $R_g = G_N M/c^2$. Find the mass of the black hole at which R_g becomes equal to its Compton wavelength $\lambda = h/mc$. Compare with Planck scale(s).

Exercise 3. Consider an electron moving with velocity $\vec{v}$ in homogeneous magnetic field $\vec{B} \perp \vec{v}$. Find the magnetic field strength at which the gyroradius becomes comparable to the de Broglie wavelength of the electron. Compare with Schwinger limit of Quantum Electrodynamics.

Exercise 4. Go through the "Units and Quantities" tutorial of astropy Python package and define a set of functions expressing measurements derived from observational data (typically in cgs units) into Natural units (in powers of eV, s or cm) and back.

Exercise 1. How can we measure direction and strength of the Earth magnetic field with a tabletop setup?

Exercise 4. The cyclotron energy/frequency moves to the X-ray range if B grows up to 10^{12} G (check).

Write down Schroedinger equation for motion of free electron in homogeneous magnetic field and find the energy spectrum of its solutions (Landau levels). Estimate magnetic field of the neutron star in V0332+53 binary system (figure on the right), assuming that wiggles of the spectrum are harmonics of the cyclortron frequency.

Exercise 5 Explore the RM dataset shown above:
https://zenodo.org/records/10963566 ; https://github.com/CIRADA-Tools/RMTable
Use astropy tools to read the FITS file of the catalog. Most of the sources in the catalog are quasars and radio galaxies. Write a script to identify them (query SIMBAD with astroquery package). Find redshifts of identified sources. How many of these sources have measured redshift?

Exercise 6. Eplore python interface to NE2001 and YMW2016 models. https://github.com/FRBs/pygedm Combine the DM estimates with RM data to estimate the strength of Galactic magnetic field in the Solar neighbourhood (consider directions toward North and South Galactic poles)

L3 Exercise 1. “Minimal energy argument”. Consider a source of size R providing synchroton luminosity L_s at frequency $\nu_s = \omega_s/2\pi$. Find an estimate of magnetic field that minimizes the total energy needed to provide the observed luminosity (energy in magnetic field plus energy in relativistic electrons).

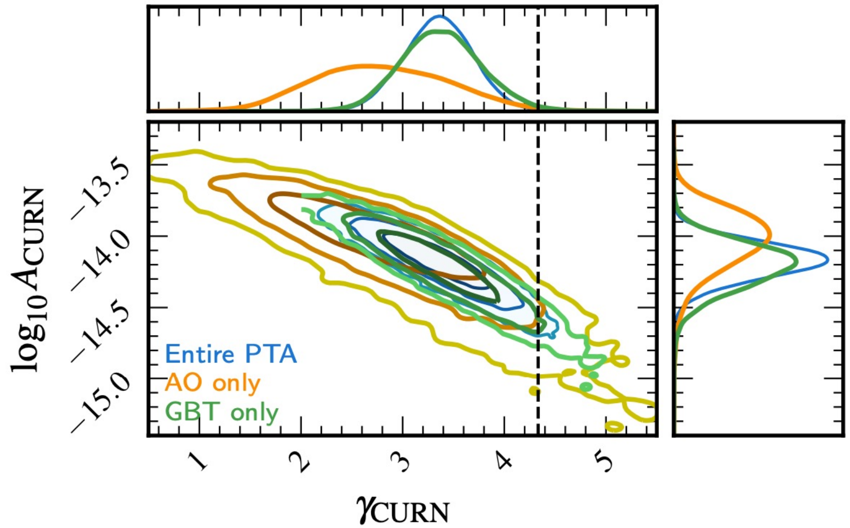
L3 Exercise 2. Download the Galactic Rotation Measure model shown in this figure, https://wwwmpa.mpa-garching.mpg.de/~ensslin/research/data/faraday2020.html , and apply it to the RM dataset studied in exercise 5 of Lecture 2 to obtain the RRM dataset. Calculate the mean and the root mean square spread of the RRM values.

L3 Exercise 3. Explore LOFAR Rotation measure catalog and extract RRM from it. Compare with the RRM from Exercise 2. https://cdsarc.cds.unistra.fr/viz-bin/cat/J/A+A/659/A1

L4 Exercise 1 Explore the public dataset of Pierre Auger Observatory https://opendata.auger.org/. Produce the sky map of UHECR event arrival directions. Locate the “Centaurus A hotspot”. What is the scale of UHECR deflections in this part of the sky in JF12 model?

L4 Exercise 2 Follow the tutorial of “data preparation” for Fermi/LAT telescope data provided by Fermi Science Support Center https://fermi.gsfc.nasa.gov/ssc/ , use this tutorial to visualise the signal of 1ES 0502+675 in 1-10 GeV band. To select the relevant data you may want to use web interface https://fermi.gsfc.nasa.gov/cgi-bin/ssc/LAT/LATDataQuery.cgi . Formulate an approach for the IGMF-dependent extended emission around the source.

L5 Exercise 1 Consider the 1-σ contour of the gravitational wave signal measurement on the right and plot the spectrum of the gravitational wave signal measurement by PTAs in $f, \Omega_{SGWB}(f)$ representation.



L5 Exercise 2. Express the sensitivities of different gravitational wave detectors in $f, \Omega_{SGWB}(f)$ representation. In cosmological context, these detectors are sensitive to the signal from different cosmological epochs (at different temperatures). Estimate the temperature ranges of sensitivity of each detector. Estimate the magnetic field strength that can be probed through the gravitational wave signature.