Seminar (ASTRO 589)
Fall 2019

Problem Set 4

Due on 18 November 2019

Homework is the central part of this course. You are encouraged to collaborate with fellow students and/or to consult senior students, local postdocs and me. But, **please write the cod/solution by yourself.** Homework is strictly due by the beginning of the class on 18 November, and **no late homework will be accepted**.

1. Let's estimate the luminosity function from the HETDEX mock data in the following directory:

   http://personal.psu.edu/duj13/ASTRO589/data/Lz_mock_#.h5

   where I stored the luminosity L, flux F, redshift z in the HETDEXmock group. The mock galaxies are for 1 sq. deg. footprint with the standard HETDEX filling factor of 1/4.5. Here's the list of fiducial cosmological parameters: $h = 0.6778$, $\Omega_{\rm m} = 0.30821$, $\Omega_\Lambda = 0.69179$.

   For simplicity, we use the fixed flux limit, $F_{\rm lim} = 3 \times 10^{-17}$ erg/cm^2/s with $\alpha = -3.5$ entering the completeness curve (called Fleming's function):

   $$p(F) = \frac{1}{2}\left[1 - \frac{2.5\alpha \log_{10}(F/F_{\rm lim})}{\sqrt{1 + (2.5\alpha \log_{10}(F/F_{\rm lim}))^2}}\right] \tag{1}$$

   (a) Choose one of the files in the folder, and plot the mock galaxies in the (L, z) plane.
   (b) Using the $1/V_{\rm max}$ method, estimate the luminosity function for all the mock realization that you choose.
   (c) Estimate the uncertainties of the measurement by using the bootstrap resampling (that is, shuffle indices allowing duplications). For the B bootstrap resamples (with index i), estimate the luminosity function using exactly same method, then estimate the variance from

   $$\sigma^2 = \frac{1}{B}\sum_{i=1}^{B}\left[\theta_i - \left(\frac{1}{B}\sum_{i=1}^{B}\theta_i\right)\right]^2 . \tag{2}$$

   (d) Finally, fit the luminosity function with the Shechter function

   $$\frac{dn}{d(L/L_\star)} = \phi_\star \left(\frac{L}{L_\star}\right)^\alpha \exp\left(-\frac{L}{L_\star}\right) \tag{3}$$

   parameters α, $\phi_\star$, $L_\star$. Find their best-fitting values and marginalized $1-\sigma$ (68 C.L.) intervals.