5. Übung zu: Astronomie & Astrophysik II

(Due: Thu., 24.6.2004)

Problem 5.1: The luminosity function of galaxies

The luminosity distribution of galaxies in the field or in clusters can be described by the luminosity function (LF). It gives the number density of galaxies as a function of their luminosity, normally given in logarithmic density and magnitudes. The LF can simply be measured from observations if distances are known.

a) Construct the luminosity function from the 200 galaxies given below. You can use mm-paper, software, or other tools, to do this. Assume that those galaxies are all the galaxies in a volume of 10 Mpc radius around the sun and that the list is complete for a certain galaxy type (see (c)) in the range $-16.5 > M > -23.5$. With this knowledge calibrate the luminosity function in absolute terms. An ASCII file with the data is available on the course webpage. Give a representation with logarithmic densities per magnitude.

b) In the 1970s Paul Schechter derived a functional form to describe luminosity functions of galaxies. It is given as

$$\phi(L)dL = \phi^* \left(\frac{L}{L^*}\right)^\gamma \exp \frac{L}{L^*} dL$$

with the space density normalisation ϕ^*, the characteristic luminosity L^* and the faint end slope γ. It can also be written in a magnitude representation

$$\phi(M)dM = \phi^* 10^{-0.4\cdot(M-M^*)(\gamma+1)} \exp\left(-10^{(-0.4\cdot(M-M^*))}\right) dM.$$

From your graph in (a) determine the faint end slope γ.

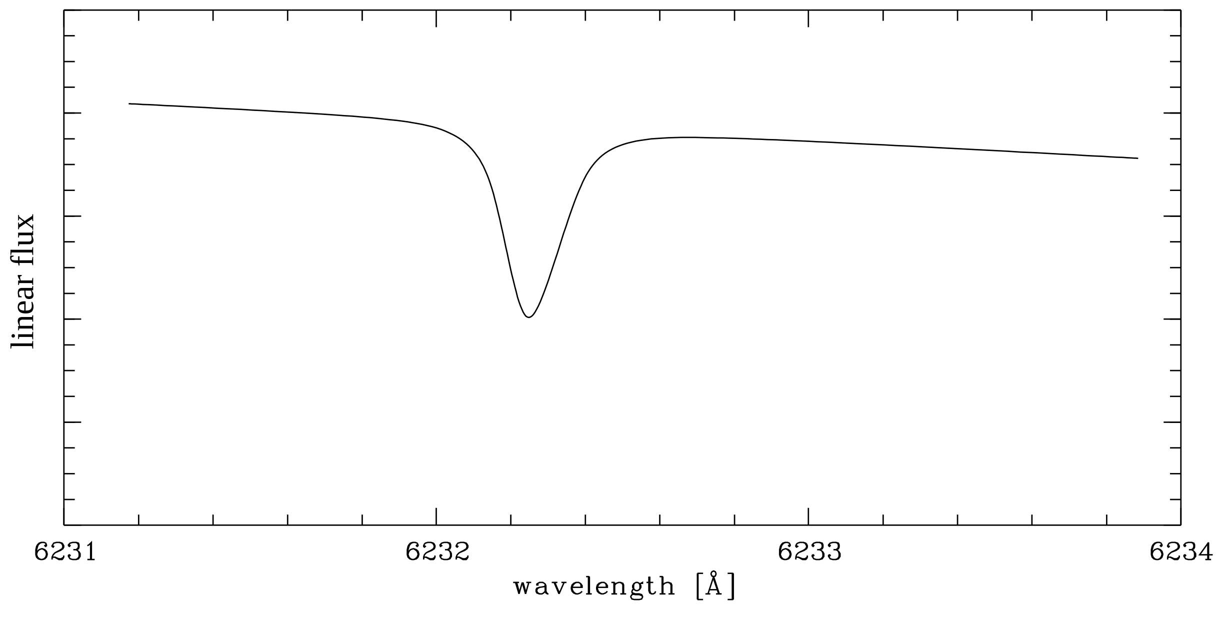
c) Spiral and elliptical galaxies have a different luminosity distribution, resulting in a different luminosity function. With the local parameters $M^*_{\text{spiral}} = 20.3$, $\phi^*_{\text{spiral}} = 0.015$ Mpc^{-3} mag^{-1} and $\gamma_{\text{spiral}} = -1.10$ for spirals, and $M^*_{\text{ell}} = 21.0$, $\phi^*_{\text{ell}} = 0.011$ Mpc^{-3} mag^{-1} and $\gamma_{\text{ell}} = -1.00$ for ellipticals, is the given galaxy sample made of ellipticals or of spirals?

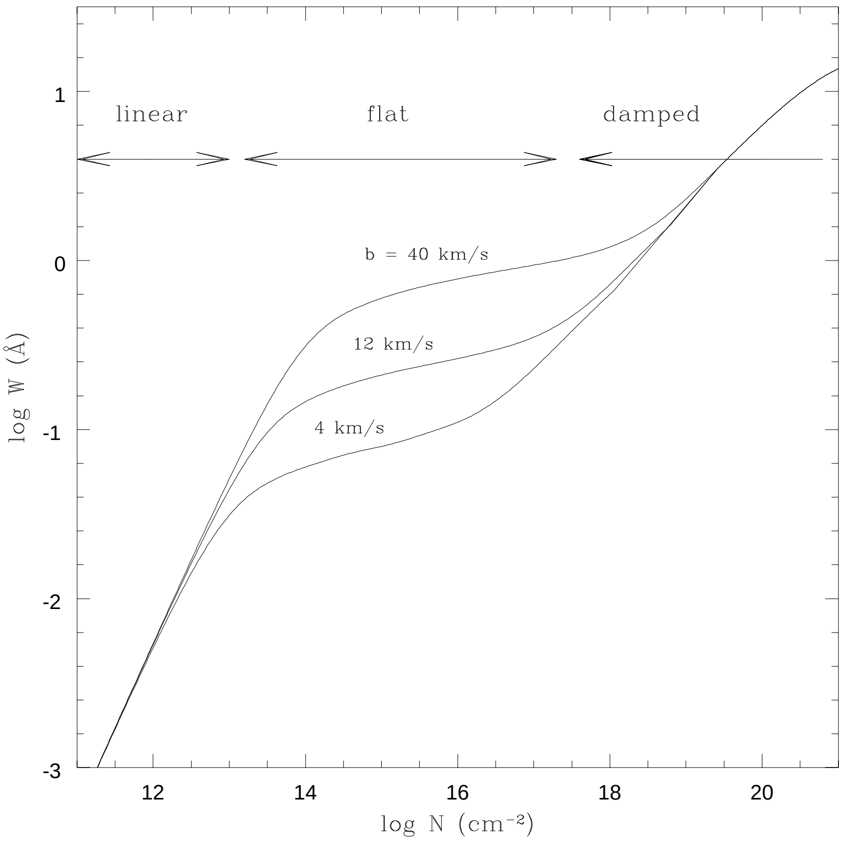
Galaxy magnitudes:

−17.7, −17.0, −21.1, −16.5, −17.1, −16.5, −17.0, −21.1, −16.6, −17.1, −20.6, −18.0, −16.6, −19.5, −17.1, −19.0, −20.7, −18.1, −16.6, −19.6, −17.2, −19.1, −20.7, −18.5, −18.1, −19.6, −16.6, −17.2, −19.1, −20.1, −22.3, −20.1, −20.8, −18.5, −16.7, −17.6, −17.2, −19.1, −17.4, −19.3, −20.8, −18.5, −16.7, −17.6, −17.2, −19.1, −17.4, −19.4, −20.9, −18.6, −16.7, −17.6, −17.2, −19.1, −19.9, −16.9, −20.9, −18.6, −16.7, −17.6, −17.3, −19.2, −19.5, −17.1, −20.3, −17.3, −19.2, −18.7, −18.3, −19.8, −16.8, −17.7, −20.3, −18.1, −19.6, −18.7, −18.3, −19.9, −16.9, −17.8, −20.3, −18.1, −19.6, −18.7, −18.4, −19.9, −16.9, −17.8, −20.4, −18.1, −19.7, −18.8, −17.8, −17.4, −19.4, −18.4, −21.2, −18.2, −19.7, −18.0, −19.0, −16.5, −17.0, −16.6, −21.0, −18.6, −17.6, −16.5, −17.1, −18.2, −19.7, −16.7, −21.0, −18.6, −17.7, −17.3, −19.2, −18.2, −19.7, −16.8, −21.2, −18.6, −18.2, −19.8, −16.8, −17.7, −17.3, −19.2, −21.3, −18.7, −18.3, −19.8, −16.8, −17.7, −17.3, −19.3, −20.3, −18.7, −18.3, −19.8, −16.8, −17.7, −17.4, −19.3, −20.4, −18.8, −18.4, −19.9, −16.9, −17.9, −17.5, −19.4, −20.4, −18.8, −18.4, −20.0, −16.9, −17.9, −17.5, −19.4, −20.5, −18.9, −18.4, −20.0, −17.0, −17.9, −17.5, −19.4, −20.5, −18.9, −18.5, −20.0, −17.0, −17.9, −17.5, −19.5, −20.6, −18.9, −21.3, −20.0, −17.9, −19.5, −20.2, −19.0, −18.9, −21.4, −20.1, −18.0, −17.4, −19.3, −20.2, −19.0, −18.9, −21.4, −20.1, −18.0, −20.2, −22.8, −20.1, −21.9

Problem 5.2: Lyman-α absorber

In the spectra of distant quasars absorption lines appear that are not connected with the quasar system. Some of them can be identified as the absorption by the Lyman-α transition of neutral hydrogen at a redshift between us and the quasar. These Lyman-α absorption system are the best diagnostics for investigating the intergalactic matter with respect to its distribution, density and composition.





a) The top figure shows a (simulated) absorption line in a quasar spectrum. Measure the equivalent width EW of the absorption line.

b) Use the bottom diagram to convert the EW into a column density of neutral hydrogen. Assume that the velocity dispersion in the cloud is low (4 km/s). Assuming further that the absorbing cloud has an extention of 10 kpc$\times$10 kpc, and that only a hydrogen fraction of 10^{-4} is neutral, compute the neutral and total hydrogen mass of the cloud.

c) What is the space density of intergalactic hydrogen if the space density of these Lyman-α absorption clouds is 15 per Mpc^3? How does this compare to the density of $2.5 \cdot 10^{-29}$ kg m^{-3} of the stars in the local universe?