Laurea Magistrale Interateneo in Fisica: **ASTROPHYSICS - 6 CFU**
Prof.: Marisa Girardi – A.A. 2016/2017

Text books and notes (in Trieste libraries or ask to the teacher):

FUNDAMENTAL ASTRONOMY, Karttunen, Kroger, Oja, et al. [**K**];

GALACTIC ASTRONOMY, Binney and Merrifield - Princ. Univ. Press, 2nd and 3rd chapters [**BM**];

GALACTIC DYNAMICS, Binney and Tremaine, (1st and 2nd eds.) - Princ. Univ. Press [**BT**] **or** [**BT2nd**]

Look at http://moodle2.units.it/course/view.php?id=436 for many notes and slides. A summary is listed in NotesSlides.README.

Suggested, too: CORSO DI ASTRONOMIA M. Hack - Hoepli [**H**]; 1st chapter of [**BM**] is an interesting reading, see http://press.princeton.edu/titles/6358.html; 1st chapter of [**BT2nd**] gives a good summary of the phenomenology of "astronomical objects"; Gary Mamon's course [M] CT2.pdf course complet http://www2.iap.fr/users/gam/M2/index.html is useful for the dynamics of galaxy systems; http://www.wolframalpha.com/ to make computations, integrals and so on.

1 Astronomical Measurements and Quantities

[K], [BM], part1.tar, [H] is useful.

Spherical Trigonometry: radiants and steradians; rectangular-spherical coordinates transformations; equations of spherical triangles. **Coordinates on the Earth**. **Celestial Coordinates**: horizontal system; equatorial systems and the sidereal time; visibility of stars and circumpolar stars; ecliptic system; galactic system; solar and sidereal day; time equation; sidereal and tropical year; exercises: angular separation and cos formula, other exercises. *[K], [H] is useful for some plots.*

Perturbations on Coordinates: effects of atmosphere - absorption and optical and radio windows, motion, refraction; aberration; parallax and **parsec (pc) as unit of distance**; precession and nutation. *[K], [H], [BM] is useful for refs. to Hipparcos.*

Motions: proper motion, redshift and radial velocity (= LOS line-of-sight velocity). *[K], [BM].*

Photometric concepts, Magnitudes and Colors: intensity, flux density and luminosity; apparent magnitudes and Pogson formula; filters and systems of magnitudes; colors; distance modulus and absolute magnitudes; magnitude corrections; absolute energy distributions and bolometric magnitudes; luminosity in solar units; mass to luminosity ratios; extinction and color excess. Exercises. *[K], [BM].*

Radiation Mechanisms and Spectra: radiation of atoms and molecules (concepts); hints to Boltzmann and Saha laws; Spectra - continuum, lines, bands; line profile and equivalent width; 21 cm line as example of forbidden line; blackbody radiation. *[K].*

2 Astronomical Objects

[K], [BM], part1.tar and part2.tar, [H] is useful only for stars.

Stars: temperatures: temperatures of the star atmosphere - color t., gradient t. effective t., excitation t. ionization t. - meaning and comparison. *[K],[H].* **Stars: spectra and classification**: Harvard classification (O,B,A...types) and discussion of main spectral features (HeII lines, HI Balmer lines; H and K CaII lines, G band); luminosity classes and the MK classification; peculiar spectra; HR and CM diagrams - hints for interpretation; Exercises with slides: 2D and 1D stellar spectra, galaxy spectra, spectra and K-correction; visual inspection of several HR/CM - diagrams. *[K],[BM].* **Binary stars**: visual - astrometric - spectroscopic binaries - photometric

binaries (=eclipsing variables) and the light curve. *[K], [BM].* **Stars: properties**: Masses of stars - mass of the Sun, mass of binary stars (visual and spectroscopic); Radii of stars - interferometry and lunar occultations (hints) - eclipsing binaries; Properties from spectra - effective temperature, surface gravity, chemical composition. **Variable stars**: Pulsating variables: Period-density relation, the cause of pulsation, most important types (Classical Cepheids and W-Virginis, RR Lyr); eruptive and cataclysmic variables (Flare stars, T Tauri, Novae, Supernovae). *[K].* Exercises.

Stellar luminosity function: luminosity function, star-counts, concepts of limited magnitude limit and magnitude limited samples, fundamental equation of stellar statistics, Malmquist bias, observational results about the luminosity function. *[BM].*

Stellar systems: Phenomenological properties of Associations, Open Clusters, Globular Clusters *[K].* Virial Theorem to estimate Cluster Mass *[K] and virialtheorem.pdf.* Distance from Moving Cluster method. Hints about Secular and statistical parallaxes *[BM].* Exercise.

Milky Way: Structure of the Galaxy: stars, stellar clusters and interstellar medium. Dynamics: the Oort constants, the rotation velocity curve and the presence of a DM halo *[K].*

Galaxies: Morphological classification. Main properties: luminosity and size, colors, spectra. Luminosity function. Tully-Fisher and Faber-Jackson relations. Structure and surface brightness profiles. Dynamics: rotation velocity and pressure supported objects. Galaxy properties and environment: cluster vs field galaxies. *[K].*

Distance Ladder: The Hubble low (V=HD) and the expansion of the Universe. The Baade-Wesselink method. A brief overview of different methods treated through the course to go from very nearby objects to very distant ones. *[K],[BM]*

Galaxy Clusters: Morphological classification. Main properties. Clusters as multicomponent objects and their multivawelenght observations: optical, X-ray, gravitational lensing. *ClustersCap1PhDthesis.pdf and others in part3.tar*

3 Galaxy dynamics - a few topics

[BT], part3.tar, [M] is an alternative to [BT].

Theory of potential: potential and gravitational field, Poisson eq., Laplace eq., and Gauss theorem in gravitation theory, the potential-energy. Spherical systems: Newton theorems, circular velocity, escape velocity, the potential of simple systems. *[BT2nd].*

Collisionless Systems: collisionless systems and relaxation time, basis of fluid mechanics. The distribution function and phase space and the collisionless Boltzmann equation. The Jeans equation and the local equilibrium. Jeans equation. *[BT].*