Laurea Magistrale Interateneo in Fisica: **SELF-GRAVITATING SYSTEMS -6CFU**
Prof.: Dr.. Marisa Girardi – A.A. 2013/2014 =48 ore
(first 18 hours M. Mezzetti)

Suggested book:

Ref. book: Old and new version of James Binney, Scott Tremaine, "Galactic Dynamics" Princeton University Press and other notes (see moodle and/or ask to the professors).

1 Introduction

Observational aspects: The Galaxy. Galaxies: properties, relations, and fundamental plane. Open clusters and globular clusters. Groups and clusters of galaxies. **Collisionless systems**: the two-body relaxation, main applications to galaxies and galaxy clusters.

2 Potential Theory

General results: potential and gravitational field, Poisson eq., Laplace and Gauss theorem in gravitation theory, the potential-energy tensor. **Spherical systems**: Newton theory., circular velocity, escape velocity, the potential of simple systems (mass point, homogeneous sphere, Plummer model, Hubble modified model, model of power low density, model of 2 power lows density, Navarro model, Sersic model). **Potential for flattened systems**: models of Kuzmin, Miyamoto and Nagai, logarithmic. potentials, eq. of Poisson in very flattened systems. **The potential of our Galaxy**.

3 The Orbits of Stars

Orbits in static spherical potentials: spherical harmonic oscillator, Keplerian potential and eq. of orbits, constant and integral of motion (hints).

4 Equilibrium of Collisionless Systems

Basis of Fluid mechanics: continuity eq., Euler eq., hydrostatic equilibrium, barotropic eq. of state, wave eq. and sound velocity, ideal gas (isothermal, adiabatic, politropic). **The collisionless Boltzmann equation**: distribution function and phase space (DF), collisionless Boltzmann equation, advantages and limitations, connection with observational quantities, "coarse grained" DF. **The Jeans theorems and spherical systems**: Jeans theorems, applications to systems with isotropic vel. dispersion tensor (politropic and Plummer models, eq. of Lane-emden, isothermal sphere, King models). Hints to more complex systems. Method to obtain the DF for a given density. **The Jeans equation and the local equilibrium**: Jeans eq., eq. in spherical coordinates and the case of a simple spherical system (stationary, non rotating, with avg. motions=0), velocity anisotropy, system mass from the Jeans eq.), connection with observational quantities (deprojection methods), practical and theoretical problems in solving the Jeans eq.). **The virial theorem and global equilibrium**: tensorial virial theorem, virial mass, "generalized" virial theorem, application: the rotation of elliptical galaxies. **Application to the internal dynamics of galaxy clusters**: the member galaxy selection, the "β problem", the M/L ratio and mass estimate, surface pressure correction to the mass, galaxy orbits and velocity anisotropy. **The choice of equilibrium**: the max entropy principle, phase mixing, violent relaxation and velocity equipartition, the gas "infall".

5 Stability of Collisionless Systems

The Jeans instability: the Jeans swindle, the Jeans instability for fluids, the Jeans instability for stellar systems infinite and homogeneous. Hints for limited and finite systems.

6 Collisions and Encounters of Stellar Systems and of Galaxy Systems

Characteristic times: es., dynamical time, crossing time, relaxation time. **Dynamical friction**: Chandrasekhar formula and applications, energy equipartition and mass segregation. **High-speed encounters and impulsive approx.**: coming back at the equilibrium and the mass loss, tidal approx., penetrating encounters, applications. **Tidal radii**. **Galaxy Mergers**: merging criteria, the structure of the remnant. **Galaxy-ICM interactions**. **Origin of cD galaxies and of the lenticulars/S0 galaxies (hints)**. **Cluster mergers**: morphology, substructure, methods of analysis in optical, X-ray, merger kinematics: bimodal model and estimate of collision parameters, thermal physics of the merger (hints): Mach number and shock waves and cold fronts, extended and diffuse radio emissions (halos and relics) and connection with merger phenomena.