ACCURATE PROPER MOTIONS AS PROBES OF DISTANCE AND DYNAMICAL STRUCTURE: THE CASE OF M13

M. WYBO AND H. DEJONGHE
Sterrenkundig Observatorium, Krijgslaan 281, Gent, Belgium

We explore the proper motion distributions of anisotropic Plummer models, and show that accurate measurements on the proper motions and radial velocity of individual stars can lead to information on the distance of a stellar system. We consider a one-parameter family of models, which all have the same Plummer law in the mass density, but have different anisotropic 2-integral distribution functions $F(E, L)$, and hence different orbital structure (Dejonghe 1986). The input data for M13 are the photometry and the radial velocities as measured by Lupton, Gunn & Griffin (1987, AJ, 91, 1114), and the proper motion data as measured by Cudworth (1979, AJ, 84, 774). We represent the distribution function as a power series expansion in Fricke-type form. The Quadratic Programming (QP)-algorithm (Dejonghe 1989, Ap.J., 343, 113) determines the coefficients in the expansion by minimising a χ^2-type variable, subject to the constraints that the distribution function must be positive in phase space. From the photometry we calculate the spatial mass density (the well-known Abel inversion) and the potential. The total mass is accounted for by applying a suitable scaling on the kinematical data. All models have a constant M/L. We use surface luminosities and the 3 (anisotropic) pressures, which depend on the three velocity dispersions. By re-iterating the procedure for various distances (and masses), the best distance estimate can be obtained.

Conclusions: Proper motions provide valuable information on orbital structure, independently of the distance. Simple inspection of the distribution of proper motion suffices to detect whether tangential orbits or radial orbits are prevalent. With a QP-algorithm we determined the distance to M13, and found agreement with previous estimates. The relative error on the distance is of the same order as the relative error on the proper motions, wherein both the accuracy in measurements and small number statistics have a contribution.

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