Galactic Dynamics in the Era of Large Surveys
Proceedings IAU Symposium No. 353, 2019
M. Valluri & J. A. Sellwood, eds.

doi:10.1017/S1743921319008287

Mapping the dark matter of NGC 2974: Combination of stellar & cold gas kinematics

M. Yang[1], L. Zhu[2], A. Weijmans[1], G. van de Ven[3,4], N. F. Boardman[5], R. Morganti[6,7] and T. A. Oosterloo[6,7]

[1]School of Physics and Astronomy, Univ. of St Andrews, North Haugh, St Andrews, KY16 9SS, UK
email: my38@st-andrews.ac.uk

[2]Shanghai Astronomical Observatory, Chinese Academy of Sciences, 80 Nandan Road, Shanghai 200030, China

[3]Department of Astrophysics, Univ. of Vienna, Türkenschanzstrasse 17, 1180 Vienna, Austria

[4]ESO, Karl-Schwarzschild-Str 2, D-85748 Garching bei Munchen, Germany

[5]Department of Physics and Astronomy, Univ. of Utah, Salt Lake City, UT 84112, USA

[6]ASTRON, Postbus 2, NL-7990 AA Dwingeloo, the Netherlands

[7]Kapteyn Astronomical Institute, Univ. of Groningen, PO Box 800, NL-9700 AV Groningen, the Netherlands

Abstract. We present a new method to combine cold gas kinematics with the stellar kinematics modelled with the Schwarzschild orbit-superposition technique, and its application to the lenticular galaxy NGC 2974. The combination of stellar and cold gas kinematics significantly improves the constraints on the measured dark matter profile: assuming a generalised NFW halo profile, we find a cuspy inner halo slope for NGC 2974.

Keywords. galaxies: structure, galaxies: kinematics and dynamics, galaxies: halos, dark matter.

1. Introduction

Dark matter haloes play an important role in the evolution of a galaxy. Multiple dynamical modelling techniques have been developed to reconstruct the gravitational potential of galaxies and detect the dark matter structure, but many have been limited by the field of view of observed stellar kinematics. Dynamical modelling with central stellar kinematics and other extended tracers is a powerful tool to model dark matter haloes (e.g. Zhu *et al.* 2016). We present a method to combine central stellar and extended cold gas kinematics, using Schwarzschild modelling. Applying this method to lenticular galaxy NGC 2974, we find that combining stellar and cold gas kinematics significantly improves the constraints on the measured dark matter profile.

2. Data

The gravitational potential of the galaxy is composed of stellar mass, a dark matter halo, and a central black hole. We generate the stellar potential from the Pan-STARRS (Chambers *et al.* 2016) r-band surface brightness of NGC 2974. We assume a generalised-NFW dark matter profile (Zhao 1996) for the halo.

The stellar kinematics were obtained with the SAURON integral-field spectropgraph (Emsellem *et al.* 2004) and modelled with the Schwarzschild orbit-superposition method (van den Bosch *et al.* 2008). The cold gas (H I) velocity map of NGC 2974 was obtained with the VLA (Weijmans *et al.* 2008).

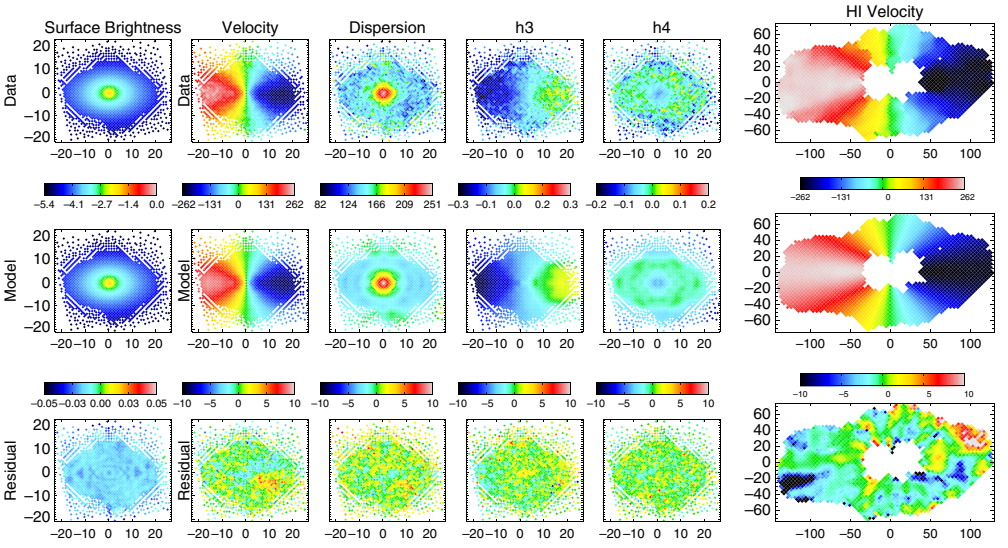

Figure 1. The data (top), model (middle) and relative residual (bottom) of the best-fitting model. Figure taken from Yang *et al.* (2020).

3. Results

We find a cuspy inner slope in NGC 2974: the corresponding best-fitting model is shown in Figure 1. The comparison of the dark matter profiles within $1-\sigma$ confidence level in models with and without cold gas kinematics (see this figure in Yang *et al.* (2019)) shows the significantly improved measurement of the dark matter profile with our combination method.

References

Chambers, K. C., Magnier, E. A., Metcalfe, N., Flewelling, H. A., Huber, M. E., Waters, C. Z., Denneau, L., Draper, P. W., Farrow, D., Finkbeiner, D. P. & others 2016, *arXiv*

Emsellem, E., Cappellari, M., Peletier, R. F., McDermid, R. M., Bacon, R., Bureau, M., Copin, Y., Davies, R. L., Krajnović, D., Kuntschner, H. & others 2003, *MNRAS*, 352, 721

van den Bosch, R. C. E., van de Ven, G., Verolme, E. K., Cappellari, M. & de Zeeuw, P. T., *MNRAS*, 385, 647

Weijmans, A., Krajnović, D., van de Ven, G., Oosterloo, T. A., Morganti, R., & de Zeeuw, P. T., *MNRAS*, 383, 1343

Yang, M., Zhu, L., Weijmans, A., van de Ven, G., Boardman, N. F., Morganti, R., & Oosterloo, T. A., 2020, *MNRAS*, 491, 4221

Zhao, H. 1996, *MNRAS*, 278, 488

Zhu, L., Romanowsky, A. J., van de Ven, G., Long, R. J., Watkins, L. L., Pota, V., Napolitano, N. R., Forbes, D. A., Brodie, J., & Foster, C. 2016, *MNRAS*, 462, 4001

https://doi.org/10.1017/S1743921319008287 Published online by Cambridge University Press