The Dark Matter Content of Barred Spiral Galaxies

Glen Petitpas, Mousumi Das, Peter Teuben, Stuart Vogel

Department of Astronomy, University of Maryland, College Park, MD, USA, 20742

Abstract:

Two-dimensional velocity fields have been used to determine the dark matter properties of a sample of barred galaxies taken from the BIMA Survey of Nearby Galaxies (SONG). By comparing the CO *J*=1-0 velocity fields with the gas flows derived from a composite barred disk + halo model we can determine several galaxy parameters that are not directly observable, such as bar pattern speed and the mass-to-light ratio (by determination of the dark matter mass). Preliminary results indicate that the maximal disk model is not appropriate in several galaxies in our sample, but this may reflect the fact that our data set is dominated by the outer radii, where the disk contribution to the total mass is smaller.

Background:

Following the work of Weiner *et al.* (2001a, 2001b) we have undertaken a study using gas kinematics to determine the dark matter properties for a sample of barred galaxies observed with the BIMA SONG survey. Typically, our velocity fields have much higher spatial coverage than the H used by Weiner *et al.*

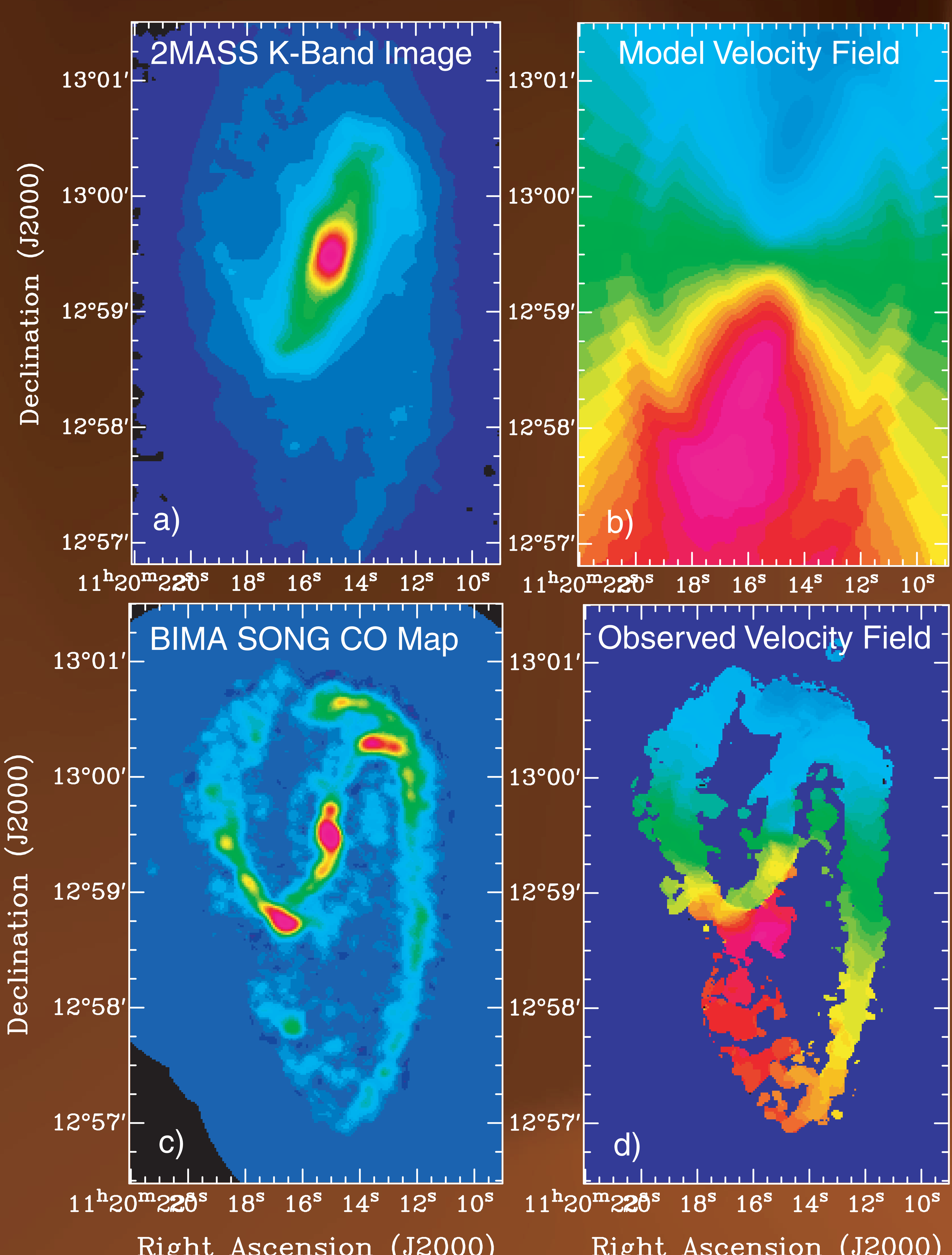

Figure 1: a) *The 2MASS image of NGC 3627 used to derive the disk contribution of the gravitational potential.* **b)** *The velocity field that results from the potential derived from the 2MASS image and assumed dark matter halo.* **c)** *Observed CO intensity map taken from the BIMA SONG survey.* **d)** *Smoothed velocity field compared to the model fields to determine the dark matter properties of this galaxy.*

Method:

Disk Potential: K-band images from the 2MASS survey are reduced and cleared of point sources, deprojected, then symmetrized by averaging flipped images in the *x* and *y* axes. These images are used to compute the 2D gravitational potential using a FFT and an assumed constant scale height (see Figure 1a).

Dark Matter: The model is parametrized by assuming a mass-to-light ratio ( ) and a softened isothermal halo to represent the complete potential in which the gas flow is traced, namely

$$_{net} = \ _{disk}(x,y) + \ _{halo}(\ _0, r_c)$$

where $$_{halo} = \ / \ 1 + (r/r_c)^2$$

Galaxy Simulations: Large grids of the hydro simulations are run for a large number of free parameters. The hydro code is describe in detail in Piner, Stone, & Teuben 1995. The simulations are smoothed to match the resolution of the galaxy to which we are comparing (Figure 1b).

Fitting: A difference map is created between each model and the data, and a ^{2} is computed and the best model is determined (see Figure 2).

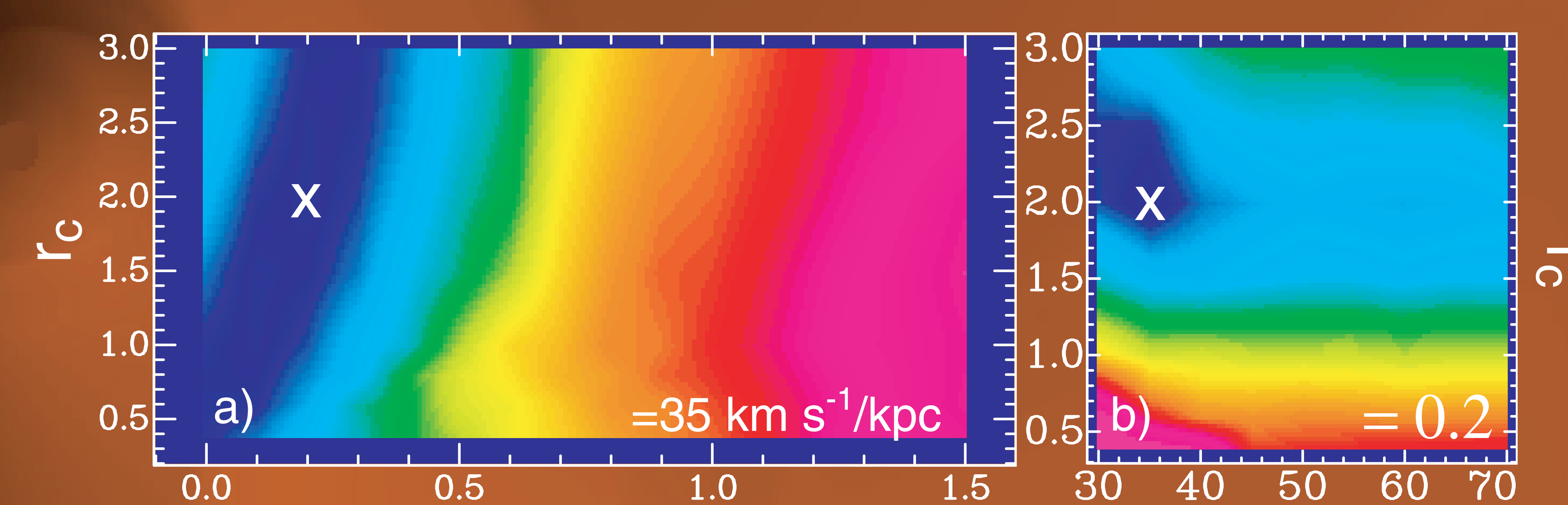

Figure 2: *Slices of the ^{2} cube through the best solution for NGC 3627. The darker blue indicates a better fit. The best solution is marked with an "x".* **a)** *Mass to light ratio plotted against dark matter core radius for the best bar pattern speed.* **b)** *Bar pattern speed plotted against dark matter core radius for the best value of mass to light ratio. We see little dependence on the bar pattern speed on the best-fit solution.*

Results:

We have determined the best fit parameters for the galaxies NGC 3627 and NGC 5457. Based on our preliminary, *low resolution* simulations we find that the maximum disk approximation is not appropriate. If fact, for NGC 5457 we find that the *minimum* disk approximation fits the data best.

For NGC 3627 we find a mass-to-light ratio = 0.2, a bar pattern speed = 35 km s^{-1}/kpc, and a dark matter core radius r_c = 2.0 kpc (see Figure 2).

Comparison of the observed CO velocity fields with forthcoming high resolution galaxy simulations will help clarify the results discussed here.

References:

Piner, B.G., Stone, J.M, & Teuben, P.J, 1995, ApJ, 448, 508

Weiner, B.J., Williams, T.B., van Gorkum, J.H., & Sellwood, J.A., 2001a, ApJ, 546, 916

Weiner, B.J., Sellwood, J.A., Williams, T.B., 2001b, ApJ, 546, 931

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