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A New Method for Corotation Determination in Spiral and Barred Galaxies

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Abstract. The approaches proposed in the past for determining the pattern speeds and corotation radii of the density waves in spiral and barred galaxies are mostly limited in their scope and accuracy. In this work, we have developed a general approach for the determination of corotation radii, which is applicable to any galaxy whose density wave modes have reached quasi-steady state – a condition empirically found to be the case for most nearby disk galaxies. The method utilizes an azimuthal phase shift between the potential and the density distributions for the density wave modes, the existence and the radial variations of which are closely related to the dynamical mechanism leading to the secular evolution of the basic state of the same disk galaxies (Zhang 1996, ApJ, 457, 125). We have used this method to derive corotation radii of over 100 galaxies using the near-infrared images of the Ohio State University Bright Galaxy Survey (OSUBGS, Eskridge *et al.* 2002, ApJS, 143, 73).

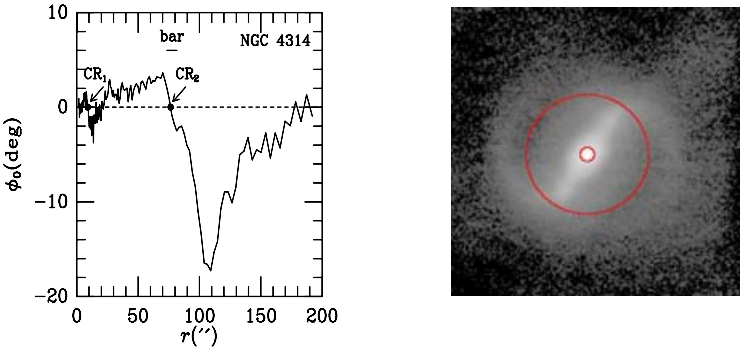

Figure 1. *Left*: Calculated phase shift versus galaxy radii for NGC 4314. Two corotation radii are indicated, as is the location of the ends of the bar. *Right*: Deprojected OSUBGS near-infrared H-band (1.65 μm) image of NGC 4314 in log scale, with the corotations determined by the phase shift method superimposed as circles.

The phase shift between the potential and density patterns for spirals or bars can be calculated from (Zhang 1996) $\phi_0 = \frac{1}{m}\sin^{-1}\left(\frac{1}{m}\frac{\int_0^{2\pi}\Sigma_1\frac{\partial\mathcal{V}_1}{\partial\phi}d\phi}{\sqrt{\int_0^{2\pi}\mathcal{V}_1^2 d\phi}\sqrt{\int_0^{2\pi}{\Sigma_1}^2 d\phi}}\right)$, where Σ_1 represents the *perturbation* density waveform and $\mathcal{V}_1$ the *perturbation* potential waveform. An example of such a calculation and the corotation radii determined from the positive-to-negative crossing of the phase shift versus radius plot is given in Figure 1. XZ acknowledges the support of the Office of Naval Research. RB acknowledges the support of NSF grant AST 050-7140 to the University of Alabama.