Determination of Pattern Speed and Star Formation Timescale in Nearby Spiral Galaxies

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We propose a method using these offsets to determine the pattern speed ($\Omega_{\rm P}$) and timescale for star formation ($t_{\rm SF}$) from molecular clouds in spiral galaxies. With simple assumptions, an angular offset θ can be written as

$$\theta = (\Omega - \Omega_{\rm P}) \times t_{\rm SF},$$

while Ω is an angular rotation velocity of materials. Since we can measure Ω and θ directory from observations, the rest two parameters, $\Omega_{\rm P}$ and $t_{\rm SF}$, can be determined by plotting θ against Ω and then fitting this plot with a line[1].

This method has been successfully applied to two grand-design spirals, M 51 (NGC 5194) and M 99 (NGC 4254). Results are listed in Table 1. For both galaxies, comparisons between CO and K-band images supported the resultant value of $\Omega_{\rm P}$, which located the corotation resonances beyond the CO arms. Derived $t_{\rm SF}$ for two galaxies were about 5 Myr, corresponding to the Jeans timescale of typical molecular clouds. Form this results, a dominant mechanism for star formation in spiral arms might be a gravitational collapse.

Table 1. Results for M 51 and M 99

	M 51	M 99
$t_{\rm SF}$ (Myr)	4.0 ± 0.5	4.8 ± 1.8
$\Omega_{\rm P}$ (km/s/kpc)	19^{+4}_{-3}	26^{+17}_{-8}
$R_{\rm CR}$	$210''$ (10 kpc)	$79''$ (6.2 kpc)

References

1. F. Egusa, Y. Sofue, H. Nakanishi: PASJ **56**, L45 (2004)