Multipole Expansion Analyses on the Central Regions of Galaxies :

toward the understanding of nuclear star formation

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1. Background of Multipole Expansion Technique

➢ In simulations

- 2D cylindrical model for disk (Aoki & Iye , 1987)

$$\begin{cases} \mu_{nm}(R,\phi) = \dfrac{Ma}{R_a^3}\dfrac{(2n+1)}{2\pi}P_{nm}(\xi)\exp(im\phi) \\ \Phi_{nm}(R,\phi) = -\dfrac{GM}{R_a}P_{nm}(\xi)\exp(im\phi) \end{cases}$$

- 3D spherical model for Early type galaxy's stellar evolution (Hernquist & Ostriker, 1992)

$$\rho_{nlm}(\boldsymbol{r}) = \frac{K_{nl}}{2\pi}\frac{r^l}{r(1+r)^{2l+3}}C_n^{(2l+3/2)}(\xi)\sqrt{4\pi}\,Y_{lm}(\theta,\phi)$$

$$\Phi_{nlm}(\boldsymbol{r}) = -\frac{r^l}{(1+r)^{2l+1}}C_n^{(2l+3/2)}(\xi)\sqrt{4\pi}\,Y_{lm}(\theta,\phi)\,,$$

- Shin & Kim (in preparation) applied this multipole expansion to describe realistic galactic structures.

➢ In observations

- **Here we model the non-axisymmetric galactic structures observed in the IR wavelengths with 2D multipole expansion technique.**

- Sample: 144 barred galaxies of Spitzer Survey of Stellar Structure in Galaxies (S4G) (Kim et al. 2014, Sheth et al.2010)

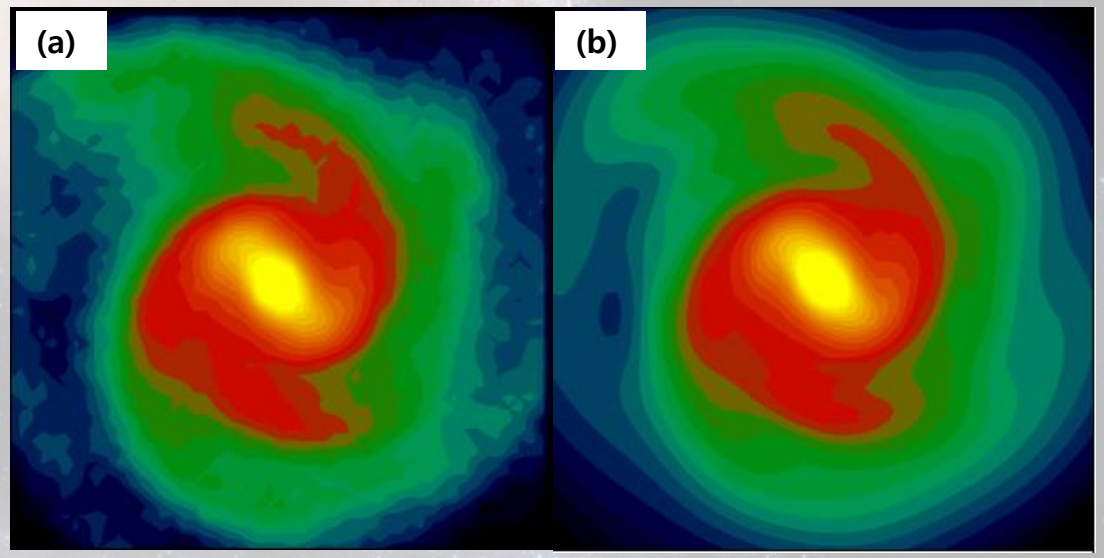


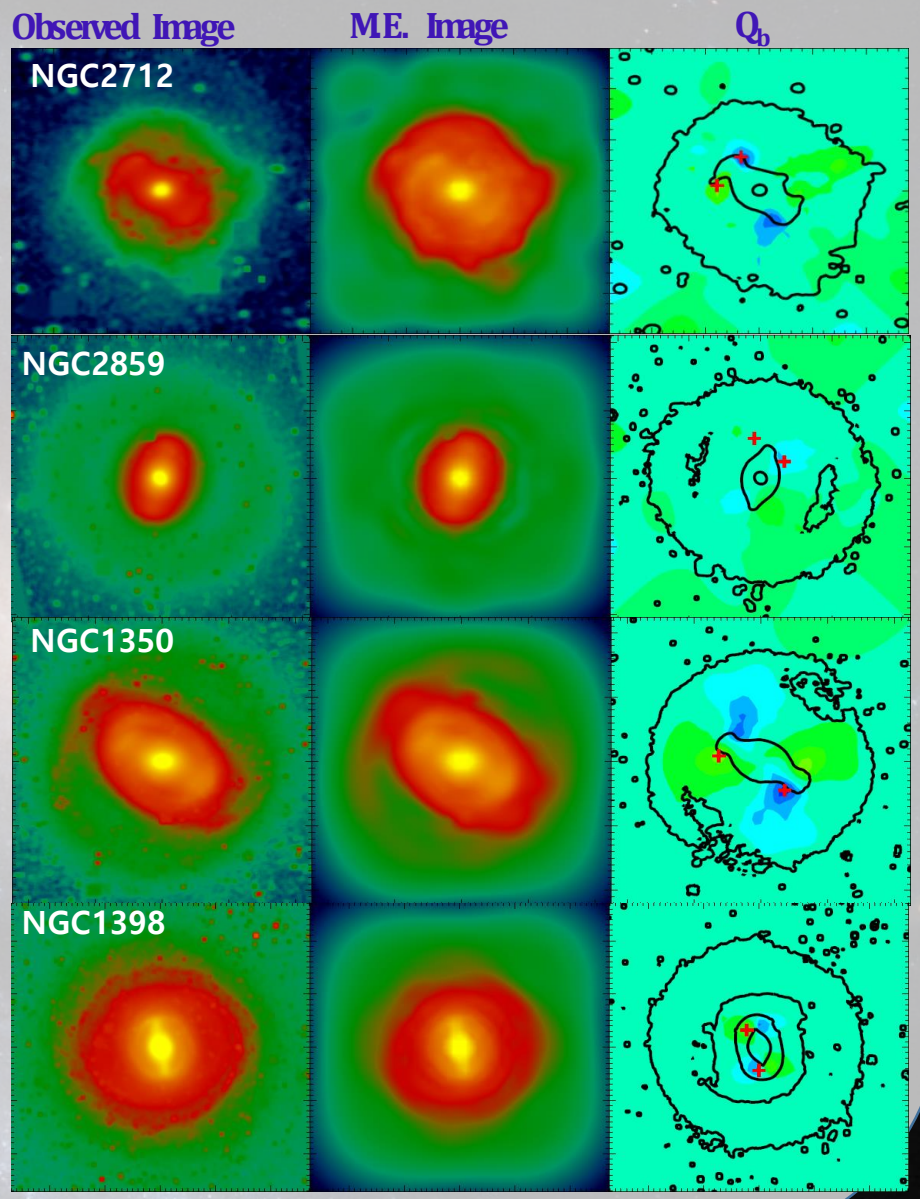
Fig 1. (a) Density map from particle distribution, (b) Density map by multipole expansion

2.Multipole Expansion on Observations

➢ Comparison with others

- Combes & Sanders (1981) : Bar strength as $Q_T(R) = \frac{F_T^{max}(R)}{<FR(R)>}$
- Buta & Block (2001) : FFT , $Q_b = \sum_{i=1}^{4}(Q_{bi}/4)$
- Seidel (2015) : Photometric torque on 14 galaxies (S4G, 3.6um).
- Laurikainen (2002): Non-axisymmetric forces of 107 spiral galaxies (2MASS, JHK-band).

	Q_b FFT	Q_b (J)	Q_b (H)	Q_b (K)	Q_b M.E
NGC2712	0.28				**0.25**
NGC2859	0.17				**0.15**
NGC1350		0.30	0.30	0.29	**0.35**
NGC1398		0.21	0.20	0.20	**0.27**



3. Future Works

➢ Coefficient Analyses

- We are in the process of studying M.E. coefficients, I_c and I_s, of large structures of galaxies, and will extend to the fine structures

➢ NuclearStar Formation

- The goal of this study is to find out the relation between the non-axisymmetry of galactic structures and the nuclear star formation.

- The non-axisymmetry information will help us to understand how gas migrates from the disk to the central region and what causes nuclear star formations.