

environments. For example, NcE galaxies are formed by tidal stripping by massive galaxies as suggested by previous studies, but DcE galaxies could be linked with high-redshift spheroids (e.g. red nuggets) which have not evolved into present-day elliptical galaxies because of the environmental influences.

### [초 GC-10] Long lived spiral structures in galaxies

Kanak Saha  
*IUCAA, India*

Spiral structure in disk galaxies is modeled with collisionless N-body simulations including live disks, halos, and bulges with a range of masses. Two of these simulations make long-lasting and strong two-arm spiral wave modes that last for about 5 Gyr with constant pattern speed. These two had a light stellar disk and the largest values of the Toomre Q parameter in the inner region at the time the spirals formed, suggesting the presence of a Q-barrier to wave propagation resulting from the bulge. The relative bulge mass in these cases is about 10%. Models with weak two-arm spirals had pattern speeds that followed the radial dependence of the Inner Lindblad Resonance. In addition to these, we also report a few more cases where two-armed spirals are developed and are maintained for a several rotation time scales.

### [구 GC-11] Gas structures and star formation in the central region of barred-spiral galaxies in self-consistent 3D simulations

Woo-Young Seo and Woong-Tae Kim  
*Seoul National University*

The central regions of barred-spiral galaxies contain interesting gaseous structures such as dust lanes and nuclear rings with intense star formation. While our previous studies were useful in understanding the formation of these structures star formation history, they were limited to 2D isothermal galaxies in which the stellar disk and halo are modeled by fixed gravitational potentials. To study the effects of bar growth as well as the vertical dimension, we use the mesh-free hydrodynamic code named GIZMO and run 3D simulations by treating the stellar disk and halo as being live. We find that the new 3D models form the gaseous features similarly to the previous 2D models, although the detailed formation processes

are quite different. For example, a ring has a large radius when it first forms and shrinks over time in the previous 2D models. In the 3D live-potential models, however, a ring forms small and grows in size with time. We present the results of the new simulations and discuss them in comparison with the previous 2D results.

### [구 GC-12] Cosmic Evolution of Disk Galaxies seen through Bars

Taehyun Kim<sup>1</sup>, Kartik Sheth<sup>2</sup>, Lia Athanassoula<sup>3</sup>, Albert Bosma<sup>3</sup>

<sup>1</sup>*Korea Astronomy Space and Science Institute*

<sup>2</sup>*NASA Headquarters*

<sup>3</sup>*Laboratoire d'Astrophysique de Marseille*

The presence of a bar in disk galaxies indicates that galaxies reached their dynamical maturity,

and secular evolution has started to play key roles in the evolution of disk galaxies. Numerical simulations predicted that as a barred galaxy evolves, the bar becomes longer by capturing its immediate neighbor disk stars. We test the hypothesis by exploring bar lengths and measuring the light deficit around the bar at various redshift. Supplementing already classified barred galaxies in later type disk galaxies ( $T \geq 2$ , Sheth et al. 2008), we classify barred galaxies among earlier type disk galaxies ( $T < 2$ ) up to  $z \sim 0.8$  using F814W images from the Cosmic Evolution Survey (COSMOS). We estimate the length of bars analytically for  $\sim 400$  galaxies, and find that there is a slight decrease in bar length with redshift. We also find that longer bars show more prominent light deficit around the bar and this trend is stronger for nearby galaxies. Our results are consistent with the predictions from numerical simulations, and imply that the bar induced secular evolution is already in place since  $z \sim 0.8$ .

### [구 GC-13] To Be or Not To Be: "We Love Galaxies" Workshop

Gwang-Ho Lee<sup>1</sup>, Jisu Kang<sup>1</sup>, Woong Lee<sup>2</sup>, Hye-Ran Lee<sup>3,4</sup>, Minbae Kim<sup>5</sup>, Jaewon Yoo<sup>3,4</sup>, Intaek Gong<sup>6</sup>, Jeong Hwan Lee<sup>1</sup>, Hyun-Jin Bae<sup>2</sup>, Suk Kim<sup>3</sup>

<sup>1</sup>*Seoul National University*, <sup>2</sup>*Chungnam National University*, <sup>3</sup>*Korea Astronomy and Space Science Institute*, <sup>4</sup>*University of Science and Technology*,

<sup>5</sup>*Kyung Hee University*, <sup>6</sup>*Sejong University*

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