Description of the 5 most significant publications (Shardha Jogee)

Below is a simplified description of the 5 most significant publications, written with a limited use of technical terms and jargon.

1. Jogee, S., Scoville, N., & Kenney, J. D. P. 2005, The Astrophysical Journal, 630, 837: *'The Central Region of Barred Galaxies: Molecular Environment, Starbursts, and Secular Evolution'*.

   The central region of galaxies hosts some of the most spectacular and energetic events known, including powerful short-lived episodes of star formation, denoted as circumnuclear starbursts. During a circumnuclear starburst, cold molecular gas in the central region of galaxies is rapidly converted into new stars, with the accompanying release of large amounts of energy within a short time. The conditions under which star formation and starbursts are triggered are not well understood. Yet, it is crucial to make headway on this issue as a proper prescription for star formation is one of the cornerstone ingredients for contemporary simulations of galaxy evolution. One major obstacle to progress is that the high resolution radio interferometric observations of cold molecular gas needed to tackle this problem are highly time consuming.

   In this paper, we combine the high resolution radio interferometric observations we collected over nine years to present one of the largest high-resolution study of molecular gas and star formation in the central region of eleven barred spiral galaxies (a common class of galaxies, which includes our own galaxy the Milky Way). We find that the central region of such galaxies host extreme molecular environments where gravitational instabilities set in only at very high gas densities, and thereupon grow rapidly. This high density, short timescale, 'burst' mode may explain why the most powerful starbursts tend to occur in the central parts of galaxies. Through modeling, we find that there appears to be a critical gas surface density below which star formation is inhibited or inefficient. We explore the dynamical resonances of the gravitational potential and show that the cold molecular gas piles up to large densities near certain resonances. Finally, we present evidence that secular drivers (i.e., internal slow processes rather than violent events, such as galaxy mergers) can drive recurrent star formation and play an important role in assembling the backbone stellar components of present-day disk galaxies. Our study provides a reference baseline for explorations of cold gas by the future Atacama Large Millimeter Array (ALMA), one of the next generation radio interferometric facilities endorsed by the National Science Foundation.

2. Jogee, S. & the GEMS team, 2004, The Astrophysical Journal Letters, 615, L105: *'Bar Evolution Over the Last Eight Billion Years: A Constant Fraction of Strong Bars in GEMS'*

   Stellar bars are recognized as the most important *internal* factor that redistributes the angular momentum of the baryonic and dark matter components of disk galaxies, thereby driving the evolution of such galaxies. While earlier works focused mainly on small samples of nearby present-day barred galaxies, this paper is one of the first attempts to put barred galaxies in a cosmological context by characterizing bars in younger galaxies at earlier epochs, when the Universe was merely half of its present age. The paper takes advantage of the large galaxy survey called GEMS, which our team carried out in 2004 with the recently installed Advanced Camera for Surveys (ACS) aboard the *Hubble Space Telescope* (*HST*). The survey provides us with high resolution, sensitive observations of large statistically significant galaxy samples to attack the problem. In this paper, we use a new machinery developed by the first author to characterize large galaxy samples, and apply it to a sample that was an order of magnitude larger than any other galaxy samples used for bar studies at those epochs. Contrary to earlier studies, our results rule out an order of magnitude decline in the fraction of strong bars over the last 8 billion years. Instead, we find that strong bars are frequent over the last 8 billion years, an interval long enough for bars to drive significant evolution of spiral galaxies. After taking into account systematic effects, our results allow for a constant or even higher bar fraction at earlier epochs.

3. Marinova, I.[1] & Jogee, S. 2007, The Astrophysical Journal, 659, 1176: *'Characterizing Bars at $z \sim 0$ in the optical and NIR: Implications for the Evolution of Barred Disks with Redshift'*

   From 2004 to 2008, the field of astronomy has been revolutionized by large galaxy surveys, enabled by the installment of the Advanced Camera for Surveys (ACS) aboard the *Hubble Space Telescope* (*HST*) in 2003. These surveys have allowed us to look back in time and directly probe the properties of statistically significant samples of young barred galaxies at early epochs, when the Universe was half of its present age. In order to nail down how galaxies evolve with time, it is necessary to combine such analyses of galaxies at early epochs with a tailored analysis of present-day galaxies (called zero redshift galaxies). In this paper, we established the local or zero-redshift reference point at both optical and near-infrared wavelengths, by performing a comprehensive quantitative analysis of present-day galaxies, using the same method that we developed for younger galaxies, and taking into account systematic effects (loss of resolution, rising obscuration, and surface brightness dimming). The local optical point we established provides the reference baseline for current galaxy surveys conducted with the *Hubble Space Telescope*. The near-infrared local point sets the stage for future surveys with the Giant Magellan Telescope (GMT) where UT is a partner, as well as NASA's flagship infrared mission, the James Webb Space Telescope (expected to launch in 2012).

4. Jogee, S., et al. 2008, The Astrophysical Journal, submitted and refereed[2]: *'History of Galaxy Interactions and their Impact on Star Formation over the Last 7 Gyr from GEMS'*

   Contemporary galaxy formation models combine the well-established Λ Cold Dark Matter (ΛCDM) cosmology, with baryonic physics to provide a general framework for galaxy evolution. The predictions on how galaxies evolve depend sensitively on the merger history of galaxies in the models, as well as the baryonic physics, and feedback effects. The merger history ultimately impacts the mass assembly, star formation history, and black hole activity of galaxies. Motivated by these considerations, this paper performs a comprehensive exploration of the observed merger history of galaxies over half of the age of the Universe. Some of our findings are: (1) We find that only $\sim 10\%$ of high mass galaxies apppear to be strongly interacting or merging over the last 7 billion years. While many earlier studies focused only on major mergers, we also provide the first estimate of the frequency of minor mergers, which actually dominate the merger rates in galaxy evolution; (2) We compare our empirical merger rate to predictions from different ΛCDM-based simulations of galaxy evolution, including the halo occupation distribution models, semi-analytic models, and smoothed particle hydrodynamics cosmological simulations. Such extensive comparisons have not been attempted to date and are long overdue. We find qualitative agreement between the observations and models, with the (major+minor) merger rate from different models bracketing the observed rate, and showing a factor of five dispersion. One can now anticipate that in the near future, improvements in both the observational estimates

[1] This is the first journal paper of graduate student I. Marinova who worked closely with the advisor, Dr. Jogee
[2] The positive referee report is included as part of the promotion files

and model predictions will start to rule out certain merger scenarios; (3) Finally, we find that, contrary to common perception and the standard textbook picture, *most of the star formation rate density over half of the age of the Universe comes from non-interacting galaxies, rather than violently interacting or merging galaxies.* This result has important implications for the known sharp shutdown in the star formation rate density of the Universe over the last seven billion years.

5. Weinzirl, T.[3], Jogee, S., Kochfar, S., Burkert, A., and Kormendy, J. 2008, The Astrophysical Journal, submitted and refereed[4]: *'Bulge n and B/T in High Mass Galaxies: Constraints on the Origin of Bulges in Hierarchical Models'*

   While the currently favored contemporary galaxy formation models provide a successful paradigm for the evolution of dark matter on large scales, several failures and areas of discord with actual observations of galaxies have been claimed. In this paper, we focus on the problem of bulge assembly and the puzzle of galaxies with low bulge-to-total (B/T) mass ratio. Bulges are central 'puffed up' stellar components in spiral galaxies, and our own galaxy has a stellar bulge in the middle of its disk. Bulges provide an important test of galaxy evolution models as their properties can constrain the relative importance of the three main modes of galaxy assembly in galaxy formation models: major mergers, minor mergers, and secular (slow internal) processes. In this paper, we derive the properties of bulges in a sample of high mass spirals using an improved technique, and find that the vast majority ($\sim 66\%$) of such galaxies have very low $B/T \leq 0.2$, with interesting structural parameters. We perform one of the first quantitative comparisons with predictions from simulations of galaxy evolution and find that, contrary to common perception, *major mergers are not the main formation pathway for bulges in high mass spirals.* In fact, the results imply that over the last 10 Gyr, *the majority of the high mass spirals have had an assembly history driven primarily by minor mergers and secular processes, rather than major mergers.*

[3]This is the first journal paper of graduate student T. Weinzirl who worked closely with the advisor, Dr. Jogee
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