INFORMATION ABOUT PRINCIPAL INVESTIGATORS/PROJECT DIRECTORS(PI/PD) and co-PRINCIPAL INVESTIGATORS/co-PROJECT DIRECTORS

Submit only ONE copy of this form **for each PI/PD and co-PI/PD** identified on the proposal. The form(s) should be attached to the original proposal as specified in GPG Section II.B. Submission of this information is voluntary and is not a precondition of award. This information will not be disclosed to external peer reviewers. ***DO NOT INCLUDE THIS FORM WITH ANY OF THE OTHER COPIES OF YOUR PROPOSAL AS THIS MAY COMPROMISE THE CONFIDENTIALITY OF THE INFORMATION.***

PI/PD Name: Shardha Jogee

Gender: ☐ Male ☒ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

Race:
(Select one or more)
- ☐ American Indian or Alaska Native
- ☒ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ White

Disability Status:
(Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☒ None

Citizenship: (Choose one) ☐ U.S. Citizen ☒ Permanent Resident ☐ Other non-U.S. Citizen

Check here if you do not wish to provide any or all of the above information (excluding PI/PD name): ☐

Pecase Eligibility: Y

REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project ☒

Ethnicity Definition:
Hispanic or Latino. A person of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race.
Race Definitions:
American Indian or Alaska Native. A person having origins in any of the original peoples of North and South America (including Central America), and who maintains tribal affiliation or community attachment.
Asian. A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.
Black or African American. A person having origins in any of the black racial groups of Africa.
Native Hawaiian or Other Pacific Islander. A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.
White. A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.

WHY THIS INFORMATION IS BEING REQUESTED:

The Federal Government has a continuing commitment to monitor the operation of its review and award processes to identify and address any inequities based on gender, race, ethnicity, or disability of its proposed PIs/PDs. To gather information needed for this important task, the proposer should submit a single copy of this form for each identified PI/PD with each proposal. Submission of the requested information is voluntary and will not affect the organization's eligibility for an award. However, information not submitted will seriously undermine the statistical validity, and therefore the usefulness, of information recieved from others. Any individual not wishing to submit some or all the information should check the box provided for this purpose. (The exceptions are the PI/PD name and the information about prior Federal support, the last question above.)

Collection of this information is authorized by the NSF Act of 1950, as amended, 42 U.S.C. 1861, et seq. Demographic data allows NSF to gauge whether our programs and other opportunities in science and technology are fairly reaching and benefiting everyone regardless of demographic category; to ensure that those in under-represented groups have the same knowledge of and access to programs and other research and educational oppurtunities; and to assess involvement of international investigators in work supported by NSF. The information may be disclosed to government contractors, experts, volunteers and researchers to complete assigned work; and to other government agencies in order to coordinate and assess programs. The information may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See Systems of Records, NSF-50, "Principal Investigator/Proposal File and Associated Records", 63 Federal Register 267 (January 5, 1998), and NSF-51, "Reviewer/Proposal File and Associated Records", 63 Federal Register 268 (January 5, 1998).

List of Suggested Reviewers or Reviewers Not To Include (optional)

SUGGESTED REVIEWERS:
Not Listed

REVIEWERS NOT TO INCLUDE:
Bruce Elmegreen (Conflict of Interest)
Ksrtik Sheth (Conflict of Interest)
Roberto Abraham (Conflict of Interest)
Sydney van den Bergh (Conflict of Interest)
Michael Regan (Conflict of Interest)

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 08-1 **NSF 08-557** **07/24/08**	**FOR NSF USE ONLY** **NSF PROPOSAL NUMBER**
FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.) **AST - MPS/AST - Special Programs in Astronomy**	

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION
				170230239	

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)	SHOW PREVIOUS AWARD NO. IF THIS IS	IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES ☐ NO ☒ IF YES, LIST ACRONYM(S)
746000203	☐ A RENEWAL ☐ AN ACCOMPLISHMENT-BASED RENEWAL	

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE **University of Texas at Austin**	ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE **University of Texas at Austin** **P.O Box 7726** **Austin, TX. 787137726**
AWARDEE ORGANIZATION CODE (IF KNOWN) **0036582000**	
NAME OF PERFORMING ORGANIZATION, IF DIFFERENT FROM ABOVE	ADDRESS OF PERFORMING ORGANIZATION, IF DIFFERENT, INCLUDING 9 DIGIT ZIP CODE
PERFORMING ORGANIZATION CODE (IF KNOWN)	

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions)
☐ SMALL BUSINESS ☐ MINORITY BUSINESS
☐ FOR-PROFIT ORGANIZATION ☐ WOMAN-OWNED BUSINESS
☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **CAREER: Galaxy Evolution in a Hierarchical Universe: Emerging Insights and Future Challenges**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ **409,319**	**60** months	**01/01/09**	

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW
☐ BEGINNING INVESTIGATOR (GPG I.G.2)
☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C)
☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.D, II.C.1.d)
☐ HISTORIC PLACES (GPG II.C.2.j)
☐ SMALL GRANT FOR EXPLOR. RESEARCH (SGER) (GPG II.D.1)
☐ VERTEBRATE ANIMALS (GPG II.D.5) IACUC App. Date ________
PHS Animal Welfare Assurance Number ________
☐ HUMAN SUBJECTS (GPG II.D.6) Human Subjects Assurance Number ________
Exemption Subsection ________ or IRB App. Date ________
☐ INTERNATIONAL COOPERATIVE ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j)
____
☐ HIGH RESOLUTION GRAPHICS/OTHER GRAPHICS WHERE EXACT COLOR REPRESENTATION IS REQUIRED FOR PROPER INTERPRETATION (GPG I.G.1)

PI/PD DEPARTMENT **Astronomy**	PI/PD POSTAL ADDRESS **2511 Speedway** **Austin, TX 78712** **United States**
PI/PD FAX NUMBER **512-471-6016**	

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Electronic Mail Address
PI/PD NAME **Shardha Jogee**	**PhD**	**1999**	**512-471-1395**	**sj@astro.as.utexas.edu**
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

CERTIFICATION PAGE

Certification for Authorized Organizational Representative or Individual Applicant:

By signing and submitting this proposal, the Authorized Organizational Representative or Individual Applicant is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding debarment and suspension, drug-free workplace, and lobbying activities (see below), nondiscrimination, and flood hazard insurance (when applicable) as set forth in the NSF Proposal & Award Policies & Procedures Guide, Part I: the Grant Proposal Guide (GPG) (NSF 08-1). Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U. S. Code, Title 18, Section 1001).

Conflict of Interest Certification

In addition, if the applicant institution employs more than fifty persons, by electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.A; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution's expenditure of any funds under the award, in accordance with the institution's conflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be disclosed to NSF.

Drug Free Work Place Certification

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Drug Free Work Place Certification contained in Exhibit II-3 of the Grant Proposal Guide.

Debarment and Suspension Certification

(If answer "yes", please provide explanation.)

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ☐ No ☒

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Debarment and Suspension Certification contained in Exhibit II-4 of the Grant Proposal Guide.

Certification Regarding Lobbying

The following certification is required for an award of a Federal contract, grant, or cooperative agreement exceeding $100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

Certification for Contracts, Grants, Loans and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, ''Disclosure of Lobbying Activities,'' in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

Certification Regarding Nondiscrimination

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative is providing the Certification Regarding Nondiscrimination contained in Exhibit II-6 of the Grant Proposal Guide.

Certification Regarding Flood Hazard Insurance

Two sections of the National Flood Insurance Act of 1968 (42 USC §4012a and §4106) bar Federal agencies from giving financial assistance for acquisition or construction purposes in any area identified by the Federal Emergency Management Agency (FEMA) as having special flood hazards unless the:

(1) community in which that area is located participates in the national flood insurance program; and
(2) building (and any related equipment) is covered by adequate flood insurance.

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant located in FEMA-designated special flood hazard areas is certifying that adequate flood insurance has been or will be obtained in the following situations:

(1) for NSF grants for the construction of a building or facility, regardless of the dollar amount of the grant; and
(2) for other NSF Grants when more than $25,000 has been budgeted in the proposal for repair, alteration or improvement (construction) of a building or facility.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME		

TELEPHONE NUMBER	ELECTRONIC MAIL ADDRESS	FAX NUMBER

*SUBMISSION OF SOCIAL SECURITY NUMBERS IS VOLUNTARY AND WILL NOT AFFECT THE ORGANIZATION'S ELIGIBILITY FOR AN AWARD. HOWEVER, THEY ARE AN INTEGRAL PART OF THE INFORMATION SYSTEM AND ASSIST IN PROCESSING THE PROPOSAL. SSN SOLICITED UNDER NSF ACT OF 1950, AS AMENDED.

CAREER ELIGIBILITY CERTIFICATIONS

A. CAREER ELIGIBILITY CERTIFICATION

To be eligible for a CAREER award, you must meet the CAREER eligibility requirements as defined in the CAREER Program Solicitation (also refer to the CAREER FAQ for further explanations). To certify your eligibility, complete each section of the CAREER checklist below. The CAREER Eligibility Certification checklist will be included as part of the proposal and will be sent to reviewers.

I certify that by the relevant July deadline for submission of CAREER proposals, I will have met all of the following criteria.

- ☒ I will hold a doctoral degree in a field of science or engineering supported by NSF
- ☒ I will be untenured
- ☒ I will not have received an NSF PECASE or CAREER award
- ☒ I will not have competed more than two times in previous NSF CAREER Program Competitions

I certify that by October 1st following the relevant July deadline for submission of CAREER proposals I will

☒ be employed in a tenure-track position

OR

☐ be employed in a tenure-track equivalent position

☒ hold the title of assistant professor

OR

☐ hold a title that is equivalent to assistant professor

☒ be employed at an institution in the U.S., its territories, or possessions, or the Commonwealth of Puerto Rico that awards degrees in a field of science or engineering supported by NSF

OR

☐ be employed at an institution in the U.S., its territories, or possessions, or the Commonwealth of Puerto Rico that is a non-profit, non-degree granting institution such as a museum, observatory, or research lab

PROJECT SUMMARY

Intellectual merit: The proposed program addresses the evolution of bars and their impact on disk galaxies over a period spanning more than half of the age of the Universe. Mounting evidence indicates that bars redistribute mass and angular momentum in disk galaxies, thereby driving their dynamical and secular evolution. While numerous studies of *small* samples of *present-day* barred galaxies exist, the proposed pioneer program will be one of the very first to push investigations of bars to *early epochs, corresponding to look-back times of up to 8 Gyr, using large samples of several thousands of galaxies.* This timely project has only recently become possible due to the completion of large, multi-wavelength surveys carried with *HST*, *Spitzer*, and *Chandra*, such as the GEMS/GOODS surveys. Furthermore, the PI has already published the first pilot results on intermediate redshift bars in GEMS, demonstrating feasibility. The proposed program will use multi-wavelength data for $\sim$ 8,000 galaxies to study how bars have evolved and how they relate to the structural properties (size, central concentration, bulge-to-disk ratio, asymmetry), circumnuclear star formation, and nuclear activity of disks out to a redshift $z \sim 1$. The empirical results will be compared to theoretical models in order to constrain scenarios of disk and bar evolution in different dark matter halos and environments. Bars in the local universe will be revisited using representative, large-volume samples from the Sloan Digitized Sky Survey. It is anticipated that this program will bring new results that will advance our understanding of disk galaxies, the evolution of the Hubble sequence, and the dramatic decline in the cosmic star formation rate since $z \sim 1$. The proposed program complements studies at $z > 2$ where the Universe appears to be dominated by major mergers, and it will provide a reference baseline for follow-up with ALMA, since it targets galaxies in the *HST/Spitzer/Chandra* Extended Deep Field South, a key legacy field for ALMA science.

Broader Impact: The proposed education outreach program, 'Building a Bridge to High School Students' aims to attract high school students into the sciences. The PI will work closely with two astronomy educators and the Mc Donald Observatory outreach division in order to develop a set of educational and outreach products that will be useful to both teachers and students. The deliverables include the creation of a set of activities which are closely linked to the PI's research on galaxy evolution; the presentation of workshops at the Conference for the Advancement of Science Teaching to train teachers to use the activities; follow-up video-conferences between the PI, high schools teachers, and students; the production of interviews with undergraduates and digital videos showing high school students the exciting opportunities in astronomy; and the creation of a website to encourage vast dissemination of these products. The activities will be pilot tested and will align with National Science Education Standards and Texas state standards. All products will be evaluated. This project will provide opportunities to learn about astronomy and research in workshops, in the classroom, and via the web and video-conferencing. It will impact thousands of teachers and an estimated 21,500 high school students located all over Texas. Many of those impacted will be minorities: Texas has the second fastest growing Hispanic demographic in the country, and 40% of 8-12th grade students in 2004-2005 were Hispanic. The proposed program uses both current research and technology in order to encourage teaching and training, and build relationships with high schools, thus creating partnerships for future projects. The benefits of this program to society include a trained and competitive scientific and technological workforce, better advocacy for research, and a more science-literate public.

TABLE OF CONTENTS

For font size and page formatting specifications, see GPG section II.C.

Appendix Items:

*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

Project Description
Galaxy Evolution in a Hierarchical Universe: Emerging Insights and Future Challenges

1. INTRODUCTION AND OVERVIEW OF THE PROGRAM

Contemporary galaxy formation models combine the well-established Λ Cold Dark Matter (ΛCDM) cosmology, which describes behavior of dark matter on very large scales, with baryonic physics to provide a general framework for galaxy evolution (e.g., Somerville & Primack 1999; Somerville et al. 2008; Cole et al. 2000; Steinmetz & Navarro 2002; White et al. 2004; Springel et al 2005a,b; Springel & Hernquist 2005; Khochfar & Burkert 2005; Maller et al. 2006) The predictions on how galaxies evolve are not unique or robust as they depend sensitively on the merger history of galaxies in the models, (which is much less well determined than the merger rates of isolated dark matter halos), the baryonic physics (e.g., gas cooling, star formation (SF), and feedback from supernovae and AGN), and to some extent on the resolution of numerical resolutions (e.g., Mayer et al. 2008). Furthermore, several areas of discord with observations have been claimed, such as the angular momentum problem (Navarro & Steinmetz 2000; Burkert & D'Onghia 2004; D'Onghia et al. 2006), the sub-structure problem, and the problem of bulgeless galaxies.

In order to glean direct insight into galaxy evolution, as well as test current models, my research program endeavors to set empirical constraints on the merger history, SF, and structural components (e.g., bars and bulges) of galaxies at different redshifts and in different environments. Furthermore, we are also attempting to shed light on the relative importance of evolution driven by secular processes, major mergers and minor mergers over the last 10 Gyr (§ 2 to 4). One of the driving philosophy behind my work is that I believe in the need for close collaborations between observers and theorists: thus, in most of my papers (e.g., Jogee et al. 1999, 2002a, 2002b, 2004, 2005, 2008; Berentzen, Shlosman, & Jogee 2006; Heiderman, Jogee, et al. 2008; Weinzirl, Jogee, Khochar, Burkert, & Kormendy 2008, hereafter WJKBK08), I perform detailed comparisons with theoretical models or/and work closely with theorists in order to advance the concurrent development of the theoretical framework.

Many of my scientific projects are enabled by large multi-wavelength galaxy surveys to which I am fortunate to have access, as a team member of five science collaborations, namely GEMS (Rix et al. 2004; http://www.mpia.de/GEMS/gems.htm); ACS-GOODS (Giavalisco et al 2004); Space Telescope Abell 901/902 Survey (STAGES; Gray et al. 2008, in prep.), the Coma Cluster HST ACS Treasury Survey (Carter et al. 2008); and NICMOS-GOODS (Conselice et al 2008, in prep.). As questions are often raised on the role of members within large collaborations, I would like to specify that my research group at UT and I are leading the science on barred galaxies in the GEMS, STAGES, Coma, and NICMOS-GOODS collaborations, and leading some of the papers on the history and impact of galaxy interactions in the GEMS, STAGES, and Coma collaborations.

While this is an ambitious program, numerous factors outlined in § **2** render it timely, and feasible: the required panchromatic dataset from ground-based surveys, *HST*, *Spitzer*, and

Chandra are already taken, reduced, and accessible to the team; the PI has already developed the tools for characterizing bars at intermediate redshifts and published the first pilot results (JO4a, b) based on ~ 1500 galaxies at $z \sim 0.2$–1.0 in the GEMS survey, thereby demonstrating the feasibility of the program; science team members have extensive complementary expertise in observations, analysis, and modeling of the structure of bars and disks. Thus, we anticipate that our program will bring important new results, which will advance our understanding of disk galaxies out to $z \sim 1$. It naturally complements studies at $z > 2$ where the Universe appears to be dominated by major mergers. With the future Atacama Large Millimeter Array (ALMA) in the offing, it is notable that this program will provide a reference baseline for follow-up with ALMA, since it targets galaxies in the *HST*/*Spitzer*/*Chandra* Extended Deep Field South, a key legacy field for ALMA science.

We also propose an education and public outreach (EPO) program, 'Exploring Galaxies and the Cosmos: A Teacher Professional Development Workshop' (§ **5**). The PI will work together with two recognized astronomy educators, and the outreach division at Mc Donald Observatory in order to develop a set of educational products for both teachers and students. In particular, we will create a set of activities that are closely linked to the PI's research on galaxy evolution using GEMS *HST* and *Spitzer* data; present workshops at the Conference for the Advancement of Science Teaching to train teachers to use the activities; offer follow-up video-conferences between the PI, high schools teachers, and students; produce interviews with undergraduates; create a digital video to show high school students the exciting opportunities for astronomy undergraduates; and create and maintain a website for the vast dissemination of these products. The activities will be pilot tested and will align with National Science Education Standards and Texas state standards. All products will be evaluated.

The rest of the proposal is structured as follows. § 2 discusses the overall feasibility of the program in terms of timeliness, observations, methodology, and team expertise. § 3.1 describes key issues and recent milestones set by our pilot study of ~ 1500 galaxies (J04a,b). § 3.2–3.5 describe the investigations central to this proposal. Our EPO program is described in § 5. Year-by-year workplans for the science program is in § 4. § 6 pertains to previous NSF support and unfunded collaborations.

2. TIMELINESS, OBSERVATIONS, METHODOLOGY, AND EXPERTISE

Several factors outlined below render this ambitious science program timely and feasible.

A. Datasets: A strong advantage is that the required data from ground-based telescopes, *HST*, *Spitzer*, and *Chandra* are already taken, reduced, and accessible to our team through the following avenues: (1) The GEMS survey, described in § 3.2, provides us with *HST* ACS images in two filters, and accurate redshifts for 8,300 galaxies down to $R_{\rm Vega} \sim 24$ at $z \sim 0.2$–1.0. (2) The *Spitzer* GTO MIPS and IRAC imaging survey covers 80% of the GEMS field. (3) The full GEMS field has been observed with *Chandra*. 75% of the field lies in the Extended Chandra Deep Field South (ECDF-S) which has been mapped by Niel Brandt and his colleagues (Lehmer et al. 2005). The remaining 25% lies in the original CDF-S (Alexander et al. 2003).

B. Methodology and pilot studies: Efficient methods to identify and *quantitatively* characterize the structure of bars at $z \sim 0.2$–1.0 (Figs. 1 and 2), along with visualization tools, have already been developed by the PI (JO4a,b). She has also demonstrated the project feasibility by publishing results (JO4a,b) based on a pilot study of $\sim$ 1500 galaxies in GEMS. This study constitutes the most extensive exploration of bars at intermediate redshifts published to date.

C. Team Expertise: Our science team is made of Jogee, Marinova, Rix, Papovich, Brandt, Peng, and Shlosman. Letters of collaboration (LOCs) are included for the last 5 members, whose unfunded contributions fall naturally within the work they are already doing. Our team has complementary expertise in observations, modeling, and interpretive studies of the structure of disk galaxies: (1) The PI, Jogee, has studied bar dynamics in both local (e.g., Jogee et al. 1995; 1998; 1999; 2002a,b; 2005) and intermediate redshift (Jogee et al. 2004a,b; Berentzen, Shlosman, & Jogee 2005) galaxies. She is a member of GEMS team and has access to the reduced data products, such as source catalogs, redshifts, structural parameters, SFRs, and mass estimates. This is outlined in the LOC from Hans-Walter Rix, the PI and project manager of GEMS; (2) Graduate student, Irina Marinova, is working with the PI since May 2005, learning the skills of the trade. She has already fitted ellipses to B-band images of 189 galaxies in the local Ohio State University Bright Galaxy Survey (OSUBGS; Eskridge et al. 2002) sample to *quantitatively* characterize properties of local bars, using the same method as used by the PI on GEMS galaxies at intermediate redshifts. She will next work with the PI on the SDSS sample and the full sample of 8,300 GEMS galaxies at $z \sim 0.2$–1.0; (3) Casey Papovich is a *Spitzer* fellow and member of the *Spitzer* GTO team. He will provide the catalog of MIPS 24 μ m sources matched with GEMS sources, the infrared luminosities, and associated images; (4) Niel Brandt will provide the catalog of *Chandra* ECDF-S X-ray sources matched to the GEMS sources, relevant X-ray properties, and associated images; (5) Chien Peng will continue to assist us in optimally using the latest version of his 2-D galaxy fitting code, GALFIT (Peng et al. 2002, 2005), in order to characterize small asymmetries and other features indicative of minor mergers (§ 3.3). (6) Isaac Shlosman has extensive theoretical and numerical experience on galactic dynamics and bars. He has collaborated with the PI on 6 papers to date. We will compare empirical results with models developed by his group (e.g. Martinez-Valpuesta, Shlosman & Heller 2004) , and other groups (e.g., Bournaud & Combes 2004; Athanassoula 2003, 2005; Shen & Sellwood 2004).

3. HISTORY AND IMPACT OF GALAXY MERGERS

The merger history of galaxies impacts the mass assembly (e.g., Dickinson et al. 2003), star formation history, AGN activity (e.g., Springel. et al. 2005b) and structural evolution of galaxies. The merger rate/fraction at $z > 1$ remains highly uncertain, owing to relatively modest volumes and bandpass shifting effects, but with a general trend towards higher merger fractions at higher redshifts Even the merger rate at $z < 1$ has proved hard to robustly measure for a variety of reasons, ranging from small samples in early studies, to different methods on large samples in later studies.

In Jogee et al. (2008a,b), we have performed a complementary and comprehensive observational estimate of the frequency of interacting galaxies over $z \sim 0.24$–0.80 (lookback times of 3–7 Gyr), and the impact of interactions on the SF of galaxies over this interval. Our study is based on *HST* ACS, COMBO-17, and Spitzer 24 μm data from the GEMS survey. We use a large sample of ~ 3600 ($M \geq 1 \times 10^9\ M_\odot$) galaxies and ~ 790 high mass ($M \geq 2.5 \times 10^{10}\ M_\odot$) galaxies for robust number statistics. Two independent methods are used to identify strongly interacting galaxies: a tailored visual classification system complemented with spectrophotometric redshifts and stellar masses, as well as the CAS merger criterion ($A > 0.35$ and $A > S$; Conselice 2003). While many earlier studies focused only on major mergers, we try to constrain the frequency of minor mergers as well, since they dominate the merger rates in ΛCDM models. Some of our results are outlined below.

Among ~ 790 high mass galaxies, *the fraction of visually-classified interacting systems over lookback times of 3–7 Gyr ranges from 9% ± 5% at $z \sim 0.24$–0.34, to 8% ± 2% at $z \sim 0.60$–0.80, as averaged over every Gyr bin.(Fig. 2a).* These systems appear to be in merging or post-merger phases, and are candidates for a recent merger of mass ratio $M1/M2 > 1/10$. The lower limit on the major ($M1/M2 > 1/4$) merger fraction ranges from 1.1% to 3.5% over $z \sim 0.24$–0.80. The corresponding lower limit on the minor ($1/10 \leq M1/M2 < 1/4$) merger fraction ranges from 3.6% to 7.5%. This is the first, albeit approximate, empirical estimate of the frequency of minor mergers over the last 7 Gyr.

For an assumed value of ~ 0.5 Gyr for the visibility timescale, it follows that *each massive ($M \geq 2.5 \times 10^{10}\ M_{\odot}$) galaxy has undergone ~ 0.7 mergers of mass ratio $> 1/10$ over the redshift interval $z \sim 0.24$–0.80. Of these, we estimate that 1/4 are major mergers, 2/3 are minor mergers, and the rest are ambiguous cases of major or minor mergers.* The corresponding merger rate R is a few $\times 10^{-4}$ galaxies Gyr^{-1} Mpc^{-3}. Among ~ 2840 blue cloud galaxies of mass $M \geq 1.0 \times 10^{9}$ $M_{\odot}$, similar results hold.

We compare our empirical merger rate R for high mass ($M \geq 2.5 \times 10^{10}\ M_{\odot}$) galaxies to predictions from different ΛCDM-based simulations of galaxy evolution, including the halo occupation distribution (HOD) models of Hopkins et al. (2007); semi-analytic models (SAMs) of Somerville et al. (2008), Bower et al. (2006), and Khochfar & Silk (2006); and smoothed particle hydrodynamics (SPH) cosmological simulations from Maller et al. (2006). To our knowledge, 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 (Fig. 2b).* One can now anticipate that in the near future, improvements in both the observational estimates and model predictions will start to rule out certain merger scenarios and refine our understanding of the merger history of galaxies.

The idea that galaxy interactions generally enhance the SFR of galaxies is well established from observations (e.g., Joseph & Wright 1985; Kennicutt et al. 1987) and simulations (e.g., Hernquist 1989; Mihos & Hernquist 1994, 1996; Springel, Di Matteo & Hernquist 2005b). However, simulations cannot uniquely predict the factor by which interaction enhance the SF activity of galaxies over the last 7 Gyr, since both the SFR and properties of the remnants in simulations are highly sensitive to the stellar feedback model, the bulge-to-disk (B/D) ratio, the gas mass fractions, and orbital geometry (e.g., Cox et al 2006; di Matteo et al. 2007). Thus, empirical constraints are needed. Among ~ 3600 intermediate mass ($M \geq 1.0 \times 10^{9}\ M_{\odot}$) galaxies, we find that *the average SFR of visibly interacting galaxies is only modestly enhanced compared to non-interacting galaxies over $z \sim 0.24$–0.80 (Fig. 2c).* This result is found for SFRs based on UV, UV+IR, and UV+stacked-IR data. This modest enhancement is consistent with the results of di Matteo et al. (2007) based on numerical simulations of several hundred galaxy collisions.

The SF properties of interacting and non-interacting galaxies since $z < 1$ are of great astrophysical interest, given that the cosmic SFR density is claimed to decline by a factor of 4 to 10 since $z \sim 1$ (e.g., Lilly et al. 1996; Ellis et al 1996; Hopkins 2004; Pérez-González et al. 2005; Le Floc'h et al. 2005). We therefore set quantitative limits on the contribution of obviously interacting systems to the UV-based and UV+IR-based SFR density over $z \sim 0.24$–0.80. Among ~ 3600 intermediate mass ($M \geq 1.0 \times 10^9$ $M_\odot$) galaxies, we find that *visibly interacting systems only account for a small fraction (< 30%) of the cosmic SFR density over lookback times of ∼ 3–7 Gyr (z ∼ 0.24–0.80; Fig. (2d))*. Our result is consistent with that of Wolf et al. (2005) over a smaller lookback time interval of ∼ 6.2–6.8 Gyr. In effect, our result suggests that *the behavior of the cosmic SFR density over the last 7 Gyr is predominantly shaped by non-interacting galaxies, rather than strongly interacting galaxies*. This suggests that the observed decline in the cosmic SFR density since $z \sim 0.80$ is largely the result of a shutdown in the SF of non-interacting galaxies.

4. THE ORIGIN OF BULGES AND THE PROBLEM OF BULGELESS GALAXIES

In ΛCDM models of galaxy evolution, there are in principle three main mechanisms to build bulges of spiral galaxies: major mergers, minor mergers, and secular processes (see WJKBK08 for details). The major merger of two spiral galaxies destroys the disk component and leaves behind a classical bulge, around which a stellar disk forms when hot gas in the halo subsequently cools, settles into a disk, and forms stars. Minor mergers can also grow bulges in several ways. A tidally induced bar and/or direct tidal torques from the companion can drive gas into the inner kpc (e.g., Quinn et al. 1993; Hernquist & Mihos 1995; Jogee 2006 and references therein), where subsequent SF forms a compact high v/σ stellar component, or disky pseudobulge. In addition, the stellar core of the satellite can sink to the central region via dynamical friction. Finally, bulges can also have a secular origin: here, a stellar bar or globally oval structure in a *non-interacting* galaxy drives gas inflow into the inner kpc , where subsequent SF forms a disky pseudobulge (e.g., Kormendy 1993; Jogee 1999; Kormendy & Kennicutt 2004; Jogee, Scoville, & Kenney 2005).

These different mechanisms to form bulges have been postulated for a long time. However, what is still missing is *a quantitative assessment of the relative importance of different bulge formation pathways* in high and low mass spirals. For instance, although bulges are an integral part of massive present-day spiral galaxies, we still cannot answer the following basic question: do most bulges in massive spirals form via major mergers, minor mergers, or secular processes?

Another thorny issue is the prevalence of bulgeless galaxies. There is rising evidence that bulgeless galaxies are quite common in the local Universe (e.g., Böker et al. 2002; Kautsch et al. 2006; BJM08a; Kormendy & Fisher 2008). Yet, in ΛCDM models of galaxy evolution, most galaxies that had a past major merger at a time when their mass was a fairly large fraction of their present-day mass, are expected to have a significant bulge. So far, no quantitative comparisons have been done between observations and model predictions to assess how serious is the challenge posed by bulgeless galaxies.

In WJKBK08, we attempt one of the first quantitative comparisons of the properties of bulges in a fairly complete sample of high mass ($M_\star \geq 1.0 \times 10^{10} M_\odot$) spirals to predictions from ΛCDM-based simulations of galaxy evolution. We derive the bulge-to-total mass ratio (B/T) and bulge Sérsic index n by performing $2D$ bulge-disk-bar decomposition on H-band images of 146 bright, high mass, moderately inclined spirals. Interestingly, we find that as many as $\sim$ 56% of high mass spirals have low $n \leq 2$ bulges: such bulges exist in barred and unbarred galaxies across all Hubble types (Fig. 3a). Furthermore a striking $\sim$ 66% of high mass spirals have $B/T \leq 0.2$ (Figs. 3a and 3b).

We compare the observed distribution of bulge B/T in high mass spirals to predictions from ΛCDM-based semi-analytical models. In the models, a bulge with $B/T \leq 0.2$ can exist in a galaxy with a past major merger, only if the last major merger occurred at $z > 2$ (lookback > 10 Gyr). The predicted fraction of high mass spirals with a past major merger and a bulge with a present-day $B/T \leq 0.2$ is *a factor of over fifteen smaller* than the observed fraction ($\sim$ 66%) of high mass spirals with $B/T \leq 0.2$. The comparisons *rule out major mergers as the main formation pathway for bulges in high mass spirals*. Contrary to common perception, *bulges built via major mergers seriously fail to account for the bulges present in $\sim$ 66% of high mass spirals*.

In the models, the majority of low $B/T \leq 0.2$ bulges exist in systems that have experienced *only minor mergers, and no major mergers*. These bulges can be built via minor mergers and secular processes. So far, we explored one realization of the model focusing on bulges built via satellite stars in minor mergers and find good agreement with the observations. Future models will explore more realistic minor merger scenarios and secular processes in paper II.

5. BARS AND THEIR IMPACT OF GALAXY EVOLUTION

(A1) Bars and their impact on the inner kpc of local nearby galaxies: 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 their dynamical and secular evolution. My early work (1998 to 2002) focused on understanding the gas inflow driven by primary and nuclear stellar bars, and the subsequent evolution of the circumnuclear region, through high resolution radio interferometric observations of the molecular gas, modeling, and complementary optical and NIR observations. These high resolution ($\sim 1''$ to $2''$ corresponding to 100–200 pc at a distance of 20 Mpc) radio interferometric observations, conducted with the Caltech OVRO mm array, are *extremely time-intensive*: typical time allocations allowed 1 or 2 galaxies to be done each year, and it takes six months to cycle through the different array configurations (C, L, H, U) needed to make a final data cube for one object. Thus, my early studies focused on individual systems, such as NGC 2782, NGC 4102, and NGC 5248 where I studied starbursts and their outflows (Jogee et al. 1998; 2003a), evolution driven by nuclear stellar bars (Jogee et al. 1999) and large-scale primary bars (Jogee et al. 2002a), and bar-driven fueling of a circumnuclear starburst ring of super-star clusters (Jogee et al. 2002b; 2003b).

Finally, putting together interferometric C0 observations collected over nine years for ten galaxies, we presented one of the largest high-resolution (150-250 pc) study of molecular gas and SF in the inner kpc of barred galaxies (Jogee, Scoville, & Kenney 2005). Our main results were as follows. (1) We showed that the inner kpc of bars differs markedly from the outer disk, hosting molecular gas surface densities of 500-3500 $M_\odot$ pc^{-2}, gas mass fractions of 10% to 30%, gas velocity dispersions of 10 to 40 km s^{-1}, and epicyclic frequencies of several 100–1000 km s^{-1} kpc^{-1}. In this environment, gravitational instabilities set in only at very high gas densities (few 100-1000 $M_\odot$ pc^{-2}), but once triggered, they grow rapidly on a timescale of a few Myrs. This high density, short timescale, 'burst ' mode may explain why the most intense starbursts tend to be in the central parts of galaxies. (2) We explored why galaxies with similar amount of molecular gas in the inner few kpc, display an order of magnitude variation in their SFR per unit molecular gas (SFR/$M_{\rm H2}$). We found two classes of systems that display low (SFR/$M_{\rm H2}$). The first class includes galaxies in the early stages of bar-driven gas inflow, where a lot of the circumnuclear gas is along the stellar bar, has large non-circular kinematics and experiences a large shear: this gas does not form stars efficiently. The second class includes galaxies that seem to be at a later stage of bar-driven gas inflow: most of the circumnuclear molecular gas is now in the inner kpc of the bar, inside its outer inner Lindbald resonance (OILR), and shows predominantly circular motions, but its surface density appears to be significantly below the Toomre critical density. In contrast, 'starbursts' or systems with high (SFR/$M_{\rm H2}$) tend to have larger gas surface densities, which are closer to the Toomre critical density over a larger region. In fact, the Toomre Q parameter reaches its minimum value in the region of SF, despite an order of magnitude variation in the gas surface density and epicyclic frequency. This suggests that the onset of gravitational instabilities, as characterized by Q, may play an important role even in the inner kpc region. (3) We investigated the distribution of molecular gas w.r.t. the dynamical resonances of the large-scale stellar bar and estimate upper limits in the range 43 to 115 km s^{-1} kpc^{-1} for the bar pattern speed and an OILR radius of $>$ 500 pc. (4) We also show evidence of disky high V/σ stellar components (so-called pseudobulges) inside the OILR of the large-scale bar, and suggest that recurrent bar-driven gas inflow and circumnuclear starbursts can contribute to the gradual buildup of such systems.

(A2) Bars as a function of redshift in the cosmological context: While the above high resolution radio interferometric studies of a small sample of nearby barred galaxies afforded important insights, and set the stage for future ALMA studies, there was a pressing need to put primary stellar bars[1] in a cosmological context and explore how their properties evolve with redshift and environment. Early Hubble Deep Field WFPC2 studies (e.g., Abraham et al 1999) sampled very small volumes, while the coarse PSF of NIC3-based studies allowed only the largest bars to be detected out to $z \sim 1$ (e.g., Sheth et al 2003). But, with the advent of large galaxy surveys conducted with the Advanced Camera for Surveys (ACS) aboard the *Hubble Space Telescope* (*HST*) as of 2003, we now had high resolution, sensitive observations of large galaxy samples to attack the problem.

One hurdle was that widely used methods to identify and characterize primary bars, such as Fourier techniques (e.g., Buta et al. 2003; 2005) and ellipse-fitting (e.g., Knapen et al. 2000; Laine et al. 2002; Jogee et al. 1999; 2002a) had only been used for manual fits of small samples of 70 to 120 galaxies, as of 2004. I therefore invested significant time in developing a bar analysis package (Jogee et al. 2004) consisting of the following: (1) An iterative adaptive tool that automates the process of ellipse-fits such that a given fit adaptively 'learns' from previous fits; (2) An interactive

[1] Primary bars, also called large-scale bars, typically have semi-major axis $a \geq 1.5$ kpc in bright massive spirals of Hubble types S0 to Sc, while secondary (nuclear) bars typically have $a < 1.0$ kpc (Laine et al. 2002; Erwin & Sparke 2002). The studies described in § A2 only focus on characterizing primary bars at intermediate redshifts.

analysis tool, where one can inspect the fitted ellipses overlaid on galaxy images, and then apply quantitative criteria to the radial profiles of ellipticity, PA, and surface brightness from ellipse fits, in order to identify and characterize the properties of primary bars and disks (ellipticity e, semi major axis a, PA, etc). These quantitative criteria are based on simulations of stellar orbits and shock loci in barred potentials.

This bar analysis package and the approach established in Jogee et al. (2004) has been *instrumental* in allowing my research group and me to perform bar analyses in samples, *which are a factor of 10 to 20 times larger* than previously done: these include 1590 galaxies out to $z \sim 1$ in the GEMS survey (Jogee et al 2004); 260 optical and NIR images in the OSU survey of local bright spirals (Marinova & Jogee 2007); 2000 late-type SDSS disk galaxies at $0.01 \leq z < 0.03$ (Barazza, Jogee, Marinova 2008a, hereafter BJM08a); 800 bright galaxies in the STAGES A901/902 supercluster survey at $z \sim 0.17$ (Marinova, Jogee, & the STAGES collaboration 2008); 500 galaxies in the ACS treasury survey of the Coma cluster at $z \sim 0.025$ (Weinzirl, Jogee, & the Coma collaboration, in prep.), and 2256 disk galaxies in the EDisCS survey (White et al. 2005) of clusters at $z \sim 0.4$–1.0 (Barazza, Jablonka, Desai, Jogee & the EDisCS collaboration 2008b).

In the first paper (Jogee et al 2004), we ellipse-fitted and analyzed 1590 galaxies over $z \sim 0.2$–1.0 drawn from 1/4 of the GEMS survey. Both F606W and F850LP images were analyzed in order to minimize shifts in the rest-frame bandpass. It is worth noting that this sample was 10 times larger than any other sample used for bar studies at the time. Three different techniques (based on Sérsic cuts, rest-frame color cuts, and concentration indices) commonly used at intermediate redshifts to identify disks were applied in order to derive the optical bar fraction (Fig. 1a). This allowed uncertainties caused by the selection of disk galaxies to be characterized. After applying inclination and absolute magnitude cuts, we found from the resulting sample of ~ 255 bright spiral galaxies that the observed optical fraction of *strong (ellipticity* $e \geq 0.4$*)* bars remains fairly constant, ranging from $(36\% \pm 6\%)$ over $z \sim 0.2$–0.7, to $(24\% \pm 4\%)$ over $z \sim 0.7$–1.0 (see Table 1 in Jogee et al. 2004). The results are shown on Fig. 1a. In particular, we do not find a dramatic order of magnitude decline in the fraction of strong ($e \geq 0.4$) bars suggested by the earlier study of Abraham et al. (1999): their Figure 4 shows that the fraction of strong bars with $e \geq 0.4$ (corresponding to $(b/a)^2 \leq 0.36$ on their Fig. 4) falls from 9/31 $(29\% \pm 10\%)$ over $z \sim 0.2$–0.7 to 0% at $z \sim 0.7$–1.0. In contrast, our results on Fig. 1a only allow for a modest factor of ~ 1.5 to 2 decline in the *observed* optical fraction of strong bars over $z \sim 0.2$–1.0 *before* correcting for the artificial loss of bars by redshift-dependent systematic effects. In effect, our results *rule out an order of magnitude decline in the fraction of strong bars over* $z \sim 0.2$ *to 1.0*: *they suggest that strong bars are frequent over the last 8 Gyr, an interval long enough for bars to drive significant evolution.*

It is important to note that our study considered only *strong* ($e \geq 0.4$) bars. This choice was motivated by the fact that strong ($e \geq 0.4$) bars have a larger impact on galaxy evolution, and can be more robustly traced over $z \sim 0.2$ to 1.0 than weak bars with ellipticity e between 0.25 to 0.40. It is encouraging to see on Fig. 1a that our results from GEMS on the *observed* optical fraction of *strong* ($e \geq 0.4$) bars over $z \sim 0.2$ to 1.0 (Jogee et al. 2004) are consistent with those reported later from a much larger sample of 2000 spirals (Sheth et al. 2008) in the COSMOS survey (although their interpretation of the results differ). In contrast, the empirical results from studies that considered all *(i.e strong+weak)* bars tend to show more divergence even at $z < 0.7$, as shown in Fig. 1b.

We complemented the GEMS study over $z \sim 0.2$ to 1.0 (Jogee et al 2004) with two studies focusing on bars at $z \sim 0$ (Marinova & Jogee 2007) and at $0.01 \leq z < 0.03$ (BJM08a), in order to nail down the rest-frame optical 'zero-redshift' point for bars (see § A3). Based on these three studies, our interpretation is that a large part, if not all, of the decline in the *observed* optical fraction of *strong* $(e \geq 0.4)$ bars over $z \sim 0{,}2$–1.0 is due to an artificial loss of bars caused by two redshift-dependent systematic effects: the decreasing spatial resolution and the increasing obscuration of bars by SF and dust as the redshift rises from 0.2 to 1.0. Locally, primary stellar bars typically have semi-major axis $a \geq 1.5$ kpc, and the majority of them have $a \leq 5$ kpc (Marinova & Jogee 2007; BJM08a). Only bars with $a \geq 2.5$ times the PSF can be robustly characterized using ellipse-fitting and our quantitative criteria for bar detection (Jogee et al. 2004), since we need to sample the bulge region, several points along the smoothly rising e and PA plateau over the bar length, and the transition to the disk. Thus, primary bars with $a > 1.5$ kpc require a minimum PSF of 600 pc for robust characterization. Since the ACS PSF ($0.1''$ in drizzled frames) drops from 300 to 800 pc from $z \sim 0.2$ to 1.0, we expect to increasingly lose bars with a in the range of 1.5 to 2.0 kpc at $z > 0.5$ (Fig. 1c). The decreasing spatial resolution alone can cause the optical bar fraction to artificially drop by a factor of 1.3 by $z \sim 1$ (e.g., Marinova & Jogee 2007; BJM08a). The second pernicious systematic effect is that the obscuration of bars by SF and dust can mask bars at optical wavelengths: even at $z \sim 0$ this effect already causes a factor of 1.3 loss in optically-visible bars (Marinova & Jogee 2007), and this loss factor X is very likely to rise with z over the interval $z \sim 0$ to 1.0, where the SFR density rises by a factor of 4 to 10 (e.g., Lilly et al .1996; Le Floc'h et al. 2005; Jogee et al. 2008; Fig. 2d). The amount by which X rises with z is presently unknown and constitutes the largest uncertainty. Thus, after taking into account systematic effects, our results allow for three possibilities, depending on how much the bar loss factor X due to obscuration by SF and dust rises with redshift: a slightly declining, a constant, or a rising bar fraction with redshift out to $z \sim 1$. In order to constrain X and help distinguish between the three possibilities, we need future work in the rest-frame NIR with WFC3 and JWST so as to trace optically-obscured bars of intermediate size (Fig. 1d).

(A3) Establishing the $z \sim 0$ point for bars in the field: We complemented the GEMS study over $z \sim 0.2$ to 1.0 (Jogee et al 2004) with two studies focusing on bars at $z \sim 0$ in order to nail down the rest-frame optical 'zero-redshift' point for bars. We first established the $z \sim 0$ reference baseline point in the rest-frame B and H bands, using 180 spirals of intermediate Hubble types (Marinova & Jogee 2007) in the OSU survey of bright spirals. We found that the bar fraction is $\sim 44\%$ in the rest-frame B-band, where dust and SF obscure about 1/3 of the bars visible in the NIR. After applying to the OSU data, the same cutoffs in magnitude, bar size, and bar ellipticity ($e_{\rm bar} \geq 0.4$), which are relevant for strong bars out to $z \sim 1$ in the GEMS survey, we find that the decreasing spatial resolution would cause the optical B-band bar fraction to fall from 44% at $z \sim 0$, to $\sim 34\%$ by $z \sim 1$ (Marinova & Jogee 2007). Allowing for a rising obscuration of bars by SF and dust with redshift, can further lower this fraction significantly. Thus, the observed decline in the optical bar fraction from $36\% \pm 6\%$ to $24\% \pm 4\%$ over $z \sim 0.2$ to 1.0 in GEMS (Jogee et al. 2004) may in large part be due to redshift-dependent systematic effects.

A similar result is obtained by BJM08a, where ~ 2000 disk galaxies in SDSS at $0.01 \leq z < 0.03$ were analyzed using the bar analysis package and quantitative criteria established in (Jogee et al 2004). This study complemented Marinova & Jogee (2007) by extending the analyses to the rest-frame r-band and to spirals of lower luminosities and later Hubble types. Interestingly we found that disk-dominated galaxies with no bulge or a very low B/D display a significantly higher optical bar fraction ($> 70\%$ vs 40%) than galaxies with prominent bulges. Furthermore, our study finds that $\sim 20\%$ of disk galaxies appear to be "quasi-bulgeless", presenting a potential challenge to ΛCDM models (see also § 4).

(A4) Bars as a function of environment: While bars in the field have been widely studied, comparatively little is known about the frequency, properties, and impact of bars in rich clusters (e.g., van den Bergh 2002; Mendez-Abreu, Aguerri, & Corsini 2008). Not only do clusters provide an interesting laboratory to test bar formation models, but bars can also be used to test the mode of cluster growth. Using the bar analysis package and quantitative approach established in Jogee et al (2004), we are currently exploring bars in clusters through three studies: a study of 800 bright galaxies in the STAGES A901/902 supercluster survey at $z \sim 0.17$ (Marinova, Jogee, & the STAGES collaboration 2008); a study of 500 galaxies in the ACS treasury survey of the rich Coma cluster at $z \sim 0.025$ (Weinzirl, Jogee, & the Coma collaboration, in prep.); and a study of 2256 disk galaxies in the EDisCS survey of clusters at $z \sim 0.4$–1.0 (Barazza, Jablonka, Desai, Jogee & the EDisCS collaboration 2008b).

Our early results from the STAGES survey suggest that the optical bar fraction in the rich A901 and A902 clusters is similar to that of the field, and shows no significant trend with any local environment tracer, such as the projected mass density κ, Σ_{10}, ICM density from X-ray emission, and the projected distance to the nearest cluster center (Marinova, Jogee, & the STAGES collaboration 2008). Similarly, no significant difference is found between the optical bar fraction of field and clusters over $z \sim 0.4$–1.0 in the EDisCS survey (Barazza et al 2008b). The latter study also finds no evidence for any strong decline in the optical bar fraction with redshift. Taken together, our results increasingly suggest that the processes controlling the frequency and properties of bars are not a strong function of environment.

6. WORK PLAN AND MILESTONES FOR SCIENCE PROGRAM

The expertise of the team (Jogee, Marinova, Rix, Papovich, Brant, Peng, Shlosman) is described in § 2. The PI (Jogee) will be responsible for the overall project management. The workplan is outlined below, and those doing the work are indicated in brackets next to each item.

Year 1 (2006): (A1) [*Marinova, Jogee*; § 3.6]: Complete the ellipse fits of *local* OSUBG galaxies in B and H bands. Classify the fits to derive the frequency and structural properties (strength, size, ratio of bar to disk size) of local bars. Publish paper on local OSUBGS bars; **(A2)** [*Jogee, Marinova*; § 3.2]: For $z \sim$ *0.2–1.0 GEMS galaxies*, classify the already-completed ellipse fits for the remaining 75% of the GEMS sample (6,200 galaxies at $z \sim 0.2$–1.0 ($T_{\rm back} \sim 2$–8 Gyr) to get frequency and structural properties. Combine with published results on the other 25% of the sample (J04b). Divide distributions in 2 Gyr redshift bins and check for evolution or invariance in properties. Publish paper.

__Year 2 (2007):__ **(B1)** [*Marinova, Jogee;§ 3.6*]: Repeat (A1) on the g and z SDSS images of ~ 4500 *local* galaxies at $z < 0.03$, taken from the SDSS DR4 NYU-VAGC. Publish paper I on SDSS bars; **(B2)** [*Jogee, GEMS team*; § 3.2D]: Using NIC3 and ACS data for $z \sim 0.2$–1.0 systems, derive the correction factor, $X_{\rm large}$, for the obscuration of *large* bars by dust at these epochs. Apply to full GEMS sample. Publish paper; **(B3)** [*Jogee, Marinova, Peng, GEMS team*; § 3.3]: For $z \sim$ *0.2–1.0 GEMS galaxies*, compare structural properties (sizes, central concentration, bulge-to-disk (B/D) ratio, mass density, and asymmetries) of barred and unbarred hosts. These structural parameters have been published or are being derived by the GEMS team (see § 3.3), and will be readily available for comparison. Establish which parameters correlate with presence of a bar. Publish paper.

__Year 3 (2008):__ **(C1)** [*Marinova, Jogee*; § 3.6 and Fig 3]: Redshift SDSS bars and quantitatively establish what types and fractions would be recovered in GEMS. Publish paper; **(C2)** [*Jogee, Marinova, Shlosman, other modelers*]: Compare results of A2+ B2+B3 with theoretical models of bar and disk evolution over cosmological times (e.g., Shlosman 2005, Bournaud & Combes 2004), and to models of secular evolution. Publish paper.

__Year 4 (2009):__ **(D1)** [*Marinova, Jogee, Papovich*; § 3.4]: Investigate relationships between bars and SFR at $z \sim 0.2$–1.0 using GEMS and *Spitzer* data. Publish paper; **(D2)** [*Jogee, Marinova*; § 3.6]: Perform corresponding analysis at $z < 0.03$ on SDSS using the Balmer indices in the NYU-VAGC, and bar properties derived in B1. Publish paper.

__Year 5 (2010):__ **(E1)** [*Jogee, Marinova, Brandt*; § 3.5] Investigate relationships between bars and AGN at $z \sim 0.2$–1.0 using GEMS and *Chandra* data. Publish paper; **(E2)** Marinova writes up thesis.

7. EPO: EXPLORING GALAXIES AND THE COSMOS – A TEACHER PROFESSIONAL DEVELOPMENT WORKSHOP

I strongly believe in a holistic approach to research, teaching, and education/outreach. In parallel with the scientific papers on the structural properties and merger history of galaxies, which my research group and I have been leading and co-leading in several large science collaborations (GEMS, STAGES, Coma ACS Treasury survey, and NICMOS-GOODS), we have also pushed for a strong education and public outreach effort. Such an effort is quintessential for sharing the scientific legacy of these surveys with the next generation of young scientists, and stimulate an inquiry based approach.

As the PI of the US-based EPO program (HST-EO-10861.35-A; 2007-2009) for the HST ACS Treasury Survey of the Coma cluster, I worked with the McDonald Observatory EPO team to reach out to teachers, K12 students, and the public at large, through 5 Stardate radio programs on the Coma cluster, which aired on May 5 to 9, 2008, to a weekly audience of over ten million people; the Universo Teacher's Guide, which is being distributed in 2008 to thousands of teachers nationally; and class activities focusing on galaxies in clusters. The Coma radio programs and HST images are being adapted for use in a ViewSpace program that will be shown in museums nationwide.

From 2006 to 2008, as the PI of our outreach program entitled 'Building a Bridge to Texas

High School Science Teachers and Students', I worked with our EPO team to develop and disseminate astronomy activities to high school students in Texas. This program was sponsored by a NASA EPO grant (NNG 06GB99G; 2006-2008) and an NSF grant (NSF AST-0607748). I extended this effort by using a FAST Tex (Faculty And Student Teams for Technology) grant for Instructional Innovation Techniques from UT to develop the Galaxies and Cosmos Explorer Tool (GCET), an online tool (http://www.as.utexas.edu/gcet/) to allow students to explore the evolution of galaxies over 8 billion years. The development of GCET was an interdisciplinary effort, where I worked with a computer science graduate student (Achal Augustine), a Division of Instructional Innovation and Assessment (DIAA) graduate student (Aaron Smith), undergraduate astronomy student (Sarah Miller – now a 2009 Rhodes scholar), astronomy educator Dr. Mary Kay Hemenway, and Sandi Preston. GCET is being used this summer in a week-long workshop to train 24 Austin Independent School District (AISD) high school teachers. It will also be used in a research class I have developed for 2009.

From 2005 to the present, I acted as adviser for 72 Astronomy undergraduates and Dean's Scholars in Astronomy at UT Austin. As of 2006, I initiated a Freshman scholarship and mentorship program to support entering students in Astronomy. Pushing this effort further, I joined forces with Computer Sciences, Math and Physics, as a co-I on a STEM proposal (DUE-0807140) to help 1st/2nd year undergraduates achieve long term success in the STEM fields of Astronomy, Computer Sciences, Math and Physics, where women and minorities are under-represented . The proposal was just awarded $600,000 by NSF in 2008. For more advanced 3rd/4th year undergraduates, involvement in research has been a cornerstone of our program. In addition to supervising the research of 5 undergraduates, I helped to set up an online system to match research skills and projects, and more recently am developing a new course entitled 'Practical Introduction to Research in Astronomy' whose goal is to better prepare undergraduates for research.

Building on our philosophy of integrating research, teaching, and education/outreach. we propose an EPO program that builds our existing exciting body of legacy datasets, activities and educational tools:

Proposed program : A strong educational component is proposed in association with this research. We request funds to conduct 5 teacher professional development workshops focusing on exploring galaxies and the cosmos for high school teachers at McDonald Observatory.

The goals of this five-year educational component are to (1) provide teacher professional development workshops for 75 teachers to offer them an experience to participate in galaxy activities in a classroom setting; (2)provide effective instructional activities on galaxies to high school teachers to use with their students

In each of years one through five, we will conduct a residential 3-day/2-night teacher's workshop for 15 teachers at the Observatory. The PI will participate in the planning of the workshop and materials and will attend a portion of the workshop, either via videoconference or in person, annually to present her research, answer questions, and interact with the participating teachers.

Since 2001, McDonald Observatory has been presenting teacher professional development workshops during the summer in Fort Davis, Texas, the beautiful mountainous site where the telescopes are located. For example, in the summer of 2008, McDonald Observatory is offering eight different professional development workshops. An example of our teacher professional development recruiting webpage and a selection of photos from 2007 workshops is available at http://mcdonaldobservatory.org/teachers/profdev/. Typically, during a summer our workshops will serve 120-150 teachers and we will have 80-100 teachers on a waiting list.

The workshops will align with the Texas Essential Knowledge and Skills[2] and the following National Science Education Standards[3] for content: 9-12 Science as Inquiry (abilities necessary to do scientific inquiry, understanding about scientific inquiry); History and Nature of Science (science as a human endeavor, historical perspectives, nature of scientific knowledge); Physical Science (interactions of energy and matter); Earth and Space Science (Origin and evolution of the universe); Science and Technology (understanding of science and technology, abilities of technical design)

They PI has already developed a rich suite of educational activities related to her research on galaxy evolution to be used in the professional development workshops. The activities include:

- *The Galaxy Cosmos Explorer Tool (GCET)* (http://www.as.utexas.edu/gcet/) an online web-based tool that encourages students to actively engage in quantitative analyses of Hubble Space Telescope (HST) images from the Galaxy Evolution from Morphology and SEDS (GEMS) survey. The tool allows users to surf the cosmos and access ACS images of over 8,000 galaxies. Users can measure the size, determine the look back time, perform morphological classification on images in two rest-frame wavelengths, and gauge the different stellar populations present. Users can record their measurements, as well as reference information, such as coordinates and redshift, into Excel spreadsheets for further analysis. Other scaffolding activities have been created to help students build their understanding of galaxies in order to use the GCET tool. These include a Galaxy Classification Activity, a Multi-wave Length Astronomy Activity, and a Lives of Stars Activity (see all at http://mcdonaldobservatory.org/teachers/classroom/Galaxies.html.) A short course workshop has already been developed about the GCET tool and delivered at the Conference for the Advancement of Science Teachers in 2008 so we have experience presenting these materials already.
- *Activities based on the HST ACS Treasury Survey of the Coma Cluster* are available at http://mcdonaldobservatory.org/teachers/classroom/ComaClusterActivity/ComaCluster.html. Their contents are derived from the PI's work with HST ACS Treasury Survey of the Coma Cluster. All activities have been extensively tested in the classroom.

Additionally, a new high school activity, that is under development and will be completed over the next year, will use content from the deep GOODS-NICMOS survey, where the PI is a co-investigator.

[2] http://www.tea.state.tx.us/teks/

[3] http://www.nap.edu/html/nses/

In addition to the classroom activities, the teachers will tour the observatory and share in the life of a research astronomer through mealtimes with the astronomers and tours of their telescope.

To meet our second goal of provide teachers with activities they can take back to the classroom, the new StarDate/Universo Teacher Guide[4], includes, among many activities, an activity on Stars and Galaxies and the PI has StarDate radio programs online that can be used in conjunction with the Teacher Guide. (These are associated with and tied to her research on the Coma Cluster research)

Other resources that will be produced over the next year that can easily be integrated into the workshop content and/or the materials that teachers take back to the classroom include a DVD on careers in astronomy and a ViewSpace museum show about the Coma Cluster research. Teachers will receive all activities presented in the workshop and expanded versions of those activities on a DVD to take back to their classroom. And finally, we arm teachers with materials they need to inspire their students to consider careers in science and technology when they get back to the classroom. Teachers take back our Department of Astronomy's undergraduate brochures (http://www.as.utexas.edu/astronomy/education/UG-Brochure-2007-1.pdf), and posters to encourage students in STEM careers. Teachers also become acquainted with the 'What are Astronomers Doing?' website (http://mcdonaldobservatory.org/research/) that describes all the projects going on at the telescopes each week.

Target Audience: The target audience for this proposal is 9th to 12th grade science teachers who have traditionally underrepresented students. While we will recruit nationally for this workshop, it should be noted that the K-12 education population in Texas is inherently diverse. In 2005-6 (the most recent year for which Texas Education Agency has published statistics), 45% of Texas's 4.5 million students were Hispanic and 14.7% were Black. Almost 56% of Texas's students were economically disadvantaged. Texas has 1,227 school districts spread out in 7,956 campuses (including charter schools).

In Texas, the degree plans that most students will use, beginning with students who were freshmen in 2007-08, will require four years of science, instead of the three previously required. At the same time, by 2012-2013, Integrated Physics and Chemistry (IPC) will be phased out of the Texas high-school curriculum. A new state-mandated Earth and Space System Science course will be offered. In addition, fourth-year students will have a new state-approved course in Astronomy among those they can take. With these changes, Texas teachers and students will have a new need for access to standards-based content and to Astronomy experts, to help them effectively deal with the new curriculum, and the PI can help fulfill this need.

Evaluation: A process and outcome evaluation is planned. We plan both a formative and summative evaluation (Frechtling & Sharp, 1997). The team will evaluate implementation to insure that the project is being carried out according to the timeline, determine whether key milestones are being met, and reflect on accomplishments. The team will formulate specific questions about outcomes achieved and lessons learned, and find appropriate methods to address these to serve both the needs of the project and NASA.

[4]http://stardate.org/pdfs/teachers/StarDate_teacher_guide_2008.pdf

Formative evaluation will consist of daily opportunities for open-ended discussion of the content and pedagogy delivered within the activities. At the conclusion of the workshops, focus groups will form to reflect on the following themes:

- How do the activities and experiences at the workshop support the participants' learning?
- How do the activities and experiences at the workshop support teaching?
- Did the workshop provide an adequate range of resources to meet the needs of the participants?

Two months after the workshop, the participants will receive a questionnaire concerning their implementation of the workshop experience. Four months after the workshop, a sample of participants will be interviewed concerning their impressions concerning the workshop and how they have implemented the workshop experience into their classrooms.

8. PRIOR NSF SUPPORT & UNFUNDED COLLABORATIONS

The P.I. is a new junior faculty member and does not have any prior support from NSF. Letters of collaboration are included for unfunded collaborators (Rix, Brandt, Papovich, Peng, Shlosman), whose specific and reasonable contributions fall naturally within the science they are already doing, as outlined in § 2.0.

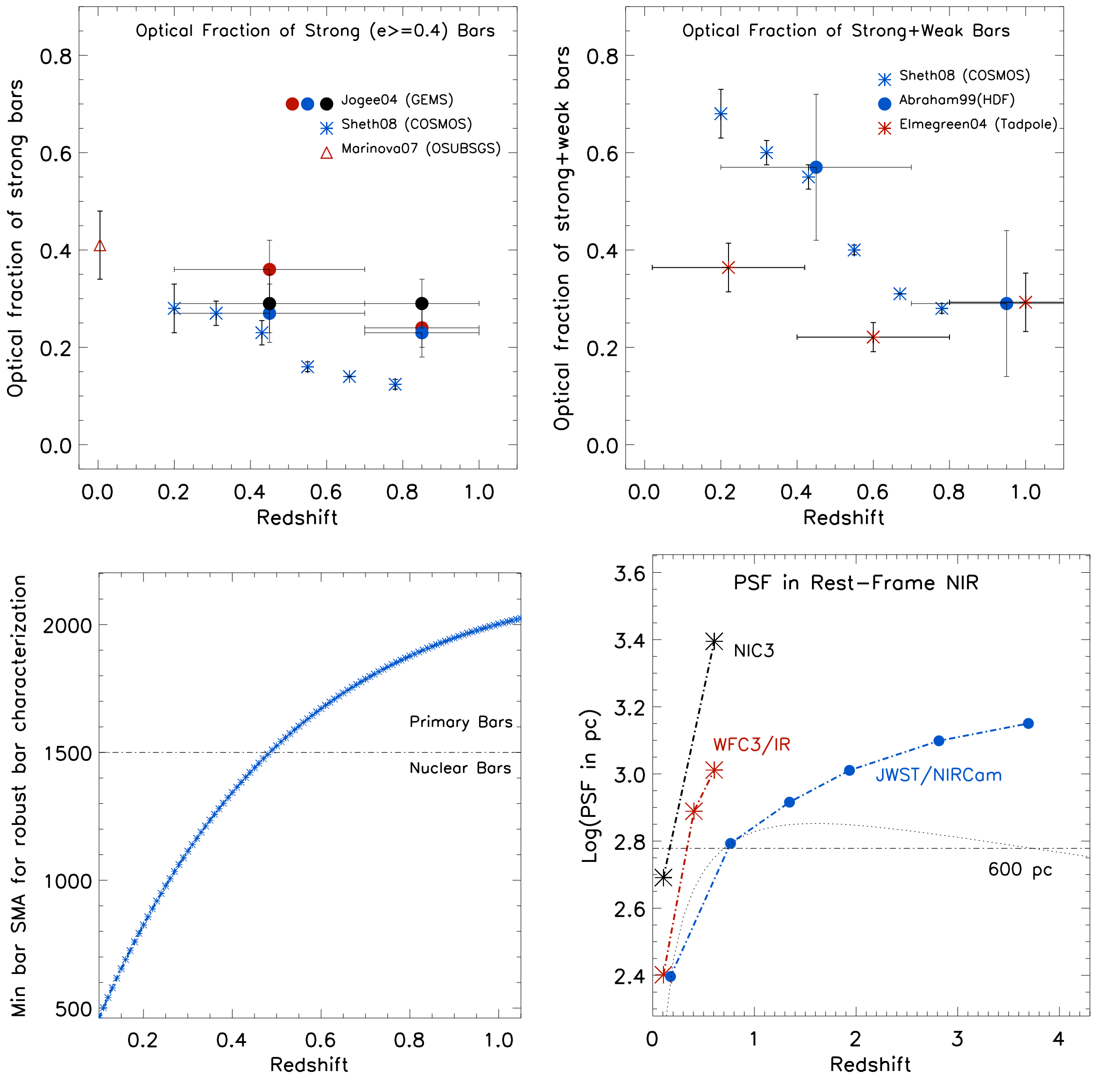


Fig. 1a (Top Left): The observed rest-frame optical fraction of *strong (ellipticity e* $\geq$ *0.4)* bars as a function of redshift is shown for the studies by Jogee et al. (2004), Marinova & Jogee (2007), and Sheth et al. (2008). The red, black, and blue filled circles show the results obtained using three commonly used techniques (based on Sérsic cuts, rest-frame color cuts, and concentration indices) to identify spiral galaxies. See § A2 for details. **Fig. 1b (Top Right):** As in 1a, but showing the observed rest-frame optical fraction of *(strong+weak)* bars. **Fig. 1c (Lower Left):** We show the minimum semi-major axis ($a_{\rm min}$) that a bar must have so that it can be robustly characterized using ellipse-fitting and the quantitative criteria in Jogee et al. (2004). We increasingly lose primary bars with a in the range of 1.5 to 2.0 kpc at $z > 0.5$. **Fig. 1d (Lower Right):** Future observations in the rest-frame NIR with WFC3 and JWST will enable us to trace optically-obscured primary bars of intermediate sizes, at the resolution (PSF) shown.

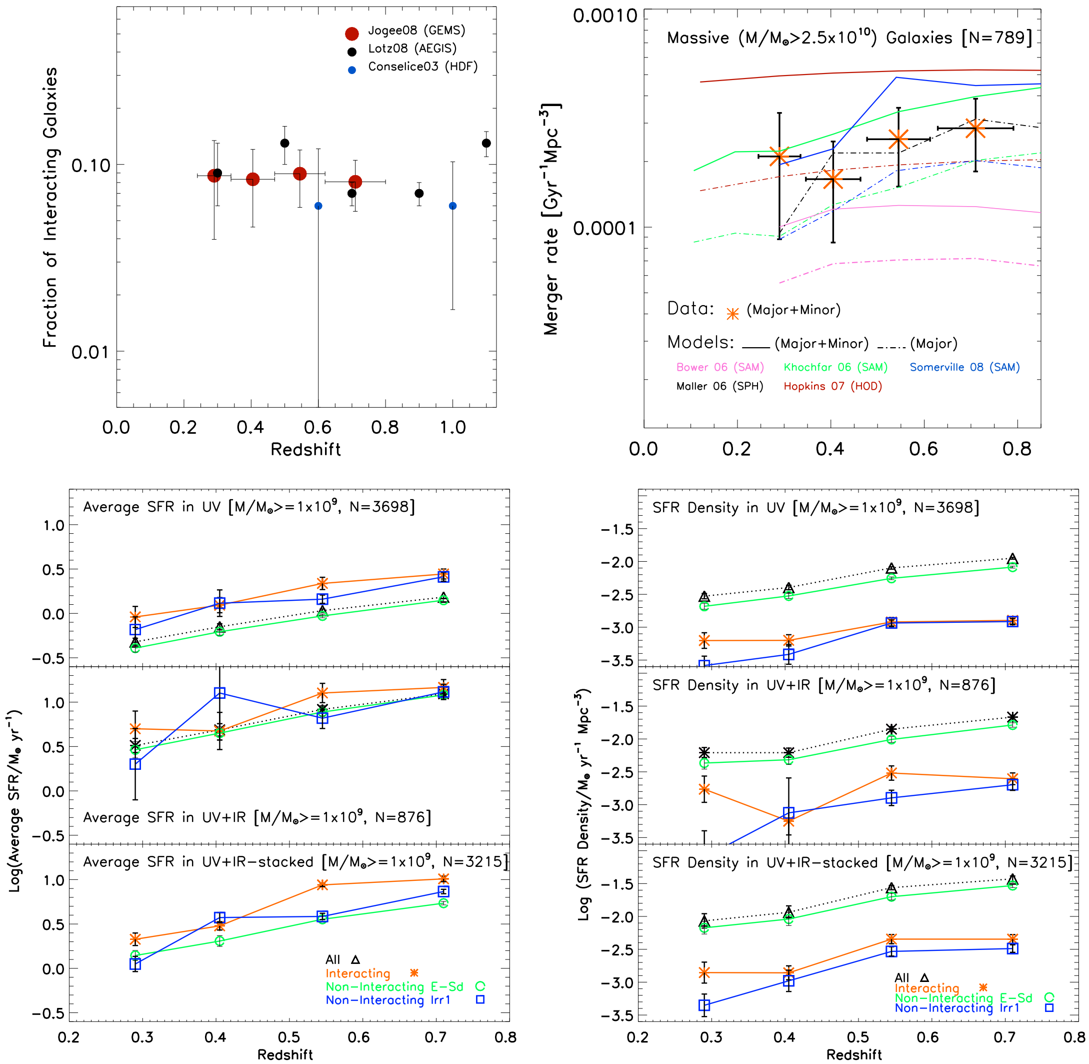
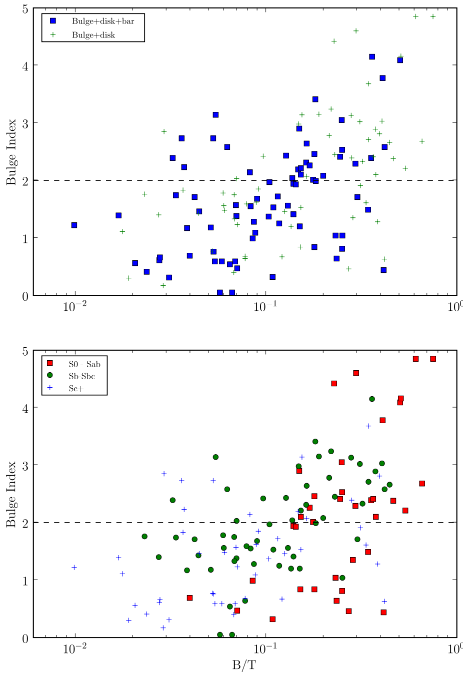


Fig. 2a (Top Left): We show the observed fraction of interacting/merging galaxies from Lotz et al. (2008), Jogee et al. (2008b), and Conselice (2003). **Fig. 2b (Top Right):** The empirical rate of galaxy mergers with mass ratio $M1/M2 > 1/10$ (orange stars) among high mass galaxies is compared to the rate of (major+minor) mergers (solid lines) predicted by different ΛCDM-based models of galaxy evolution. **Fig. 2c (Lower Left):** The average SFR of interacting and non-interacting galaxies are compared. The average UV-based SFR (top panel; based on 3698 galaxies), average UV+IR-based SFR (middle panel; based on only the 876 galaxies with 24um detections), and average UV+IR-stacked SFR (based on 3215 galaxies with 24um coverage) are shown. In all there cases, the average SFR of interacting galaxies is only modestly enhanced compared to non-interacting E-Sd galaxies over $z \sim 0.24$–0.80 (lookback time $\sim$ 3–7 Gyr). **Fig. 2d (Lower Right):** As in. 2c, but now showing the SFR density of galaxies. In all bins, interacting galaxies only contribute a small fraction (typically below 30%) of the total SFR density. [All figures are from Jogee et al (2008b)]



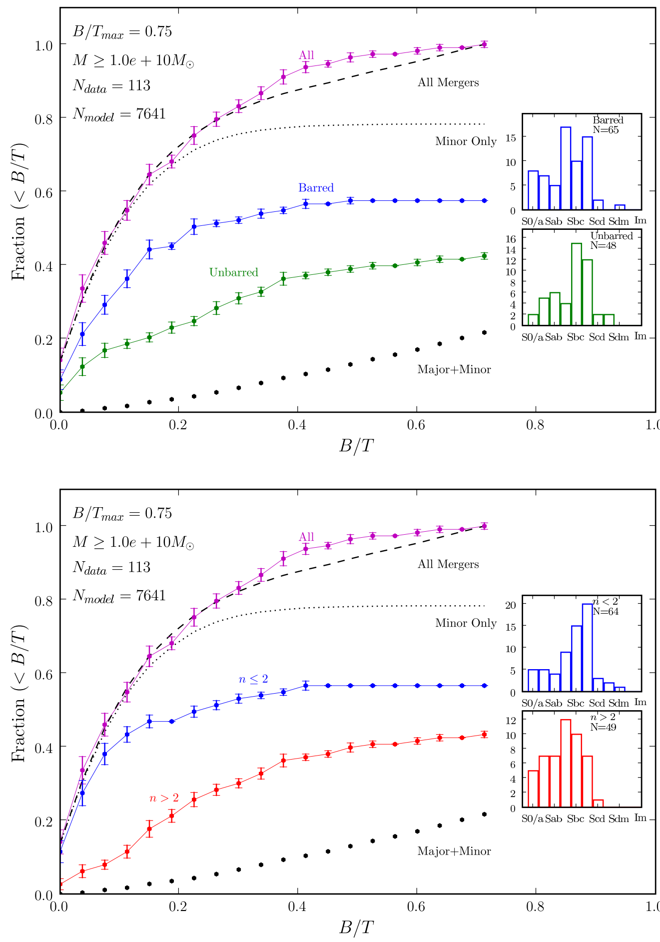


Fig. 3a (Left): The relation between B/T and bulge index is shown. The legend indicates the type of decomposition used for each data point. Note that as many as 60% of bright spirals have low $n \leq 2$ bulges: such bulges exist in barred and unbarred galaxies across all Hubble types, and their B/T ranges from 0.01 to 0.4, with most having $B/T \leq 0.2$. **Fig. 3b (Right):** For high mass ($M_\star \geq 1.0 \times 10^{10} M_\odot$) spirals, we compare the empirical distribution of bulge-to-total mass ratio (B/T) to predictions from ΛCDM-based simulations of galaxy evolution. The y-axis shows the *cumulative* fraction F of galaxies with $B/T \leq$ a given value. The magenta line shows F from the data, while the other two colored lines break this F in terms of bar class (top panel) or bulge n (lower panel) The black dashed line shows F from all model galaxies, while the black dotted line and black dots show the contribution of model galaxies that experienced, respectively, *only past minor mergers* and *both major and minor mergers*. In the models, the fraction ($\sim$ 3%) of high mass spirals, which have undergone a past major merger and host a bulge with $B/T \leq 0.2$ is *a factor of over 15 smaller* than the observed fraction ($\sim$ 66%) of high mass spirals with $B/T \leq 0.2$. Thus, *bulges built via major mergers seriously fail to account for most of the low $B/T \leq 0.2$ bulges present in $\sim$ 66% high mass spirals.* [All figures are from Weinzirl, Jogee, Khochar, Burkert, & Kormendy (2008)]

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BIOGRAPHICAL SKETCH OF PI (Shardha Jogee)

Professional Preparation

- Cambridge University, England – Physics – B.A. Honors (1992), M.A. (1995)
- Yale University, U.S.A – Astronomy – M. S. (1994), M. Phil. (1994), Ph.D. (1999)
- CalTech, U.S.A – Astronomy – Postdoctoral Scholar, Nov 1998 -June 2002

Appointments

- Sep. 2004–Present: Assistant Professor (tenure-track), University of Texas at Austin
- July 2002–Sep. 2004: Astronomer (tenure-track), Space Telescope Science Institute

Selected Publications

1. Jogee, S., Miller, S., Penner, K., Skelton, R. E., Conselice, C. J., Somerville, R. S., Bell, E. F.,the GEMS collaboration, 2008, ApJ, submitted: *'History of Galaxy Interactions and Their Impact on Star Formation over the Last 7 Gyr from GEMS'* [Submitted copy at *www.as.utexas.edu/∼sj/pt/interactions-sf-GEMS.2008.pdf*]
2. Weinzirl, T., Jogee, S., Khochfar, S., Burkert, A., & Kormendy, J. 2008, ApJ, submitted (arXiv:0807.0040): *'Bulge n and B/T in High Mass Galaxies: Constraints on the Origin of Bulges in Hierarchical Models'*
3. Jogee, S., Barazza, F., Rix, H.-W., Shlosman, I., Barden, M., Wolf, C. W., Davies, J., Heyer, I., Beckwith, S. V. W., Bell, E. F., et. al. 2004, ApJl, 615, L105: *Bar Evolution Over the Last Eight Billion Years: A Constant Fraction of Strong Bars in GEMS*
4. Jogee, S., Scoville, N. Z., & Kenney, J. D. P. 2005, ApJ, 630: *'The Central Region of Barred Galaxies: Molecular Environment, Starbursts, and Secular Evolution'*
5. Heiderman, A., Jogee, S., et al., & the STAGES collaboration, 2008, ApJ, in prep.: *'Properties and Impact of Interacting Galaxies in the Abell 901/902 Supercluster from STAGES' (submission by Aug 20, 2008)'* [Draft in final pass at *www.as.utexas.edu/∼sj/pt/interactions-STAGES.pdf*]
6. Marinova, I. & Jogee, S. 2007, ApJ, 659, 1176: *'Characterizing Bars at $z \sim 0$ in the optical and NIR: Implications for the Evolution of Barred Disks with Redshift'*
7. Marinova, I., Jogee, S., et al., & the STAGES collaboration, 2008, ApJ, in prep.: *'The Properties of Barred Disks in a Supercluster Environment: Constraints from Abell 901/2 with STAGES (submission by Aug 20, 2008)'* [Draft in final pass at *www.as.utexas.edu/∼sj/pt/bars-STAGES.pdf*]
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9. Jogee, S., Kenney, J. D. P., & Smith, B. J. 1999, ApJ, 526, 665 (astro-ph/9907085): *'A nuclear bar feeding molecular gas into a powerful central starburst in NGC 2782'*
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Synergistic Activities

1. Adviser for 72 Astronomy undergraduates and Advisor for Dean's Scholars UT Austin (May 2005–Present); Initiated a Freshman scholarship and mentorship program to support entering students in Astronomy (2006-2008); Co-I of STEM proposal (DUE-0807140) to help 1st/2nd year undergraduates achieve long term success in STEM fields, where women and minorities are under-represented (awarded $600,000 by NSF in 2008). Initiated and developed a new course entitled 'Practical Introduction to Research in Astronomy' for 2008-09, to prepare undergraduates for research.
2. Led the US-based EPO program for the HST ACS Treasury Survey of the Coma cluster. Deliverables include 5 Stardate radio programs on the Coma cluster, which aired on May 5 to 9, 2008, to a weekly audience of over ten million people; the Universo Teacher's Guide for thousands of teachers nationally; and class activities focusing on galaxies in clusters.
3. Led an outreach program (funded by NSF and NASA) entitled *'Building a Bridge to Texas High School Science Teachers and Students'* from 2006 to 2008. Used a UT Award for Instructional Innovation Techniques (2006) to push this effort further by developing the *Galaxies and Cosmos Explorer Tool (GCET)*, an online tool *(http://www.as.utexas.edu/gcet/)* to students to actively engage in exploring the evolution of galaxies over a large fraction of the age of the Universe.
4. Member of Scientific Organizing Committee for (1) Conference on 'Galaxy Evolution: Emerging Insights and New Challenges', to be held at UT Austin in Nov. 2008; (2) Conference on Galaxy Dynamics along the Hubble sequence, to be held in Italy in Aug. 2008; (3) The 3rd North American ALMA Science Center Meeting, to be held in mid-2009.
5. Member of four large science collaborations (GEMS, STAGES, Coma ACS Treasury survey, and NICMOS-GOODS) where my research group and I are leading the papers on barred galaxies and some of the papers on the history and impact of galaxy interactions. Member of the home planning team for the *public* Hubble Ultra Deep Field (HUDF) in 2004.

Collaborators and Other Affiliations:

- *Collaborators and co-editors* – F. Barazza (UT), D. Bacon (Portsmouth), M. Balogh (Waterloo), M. Barden (MPIA), E. Bell (MPIA), S. Beckwith (STScI), J. A. R. Caldwell (UT), D. Carter (Liverpool), C. Conselice (Nottingham), M. Dickinson (NOAO), H. Ferguson (STScI), M. Giavalisco (UMass), Gray M. E. (Nottingham), B. Häußler (Nottingham), C. Heymans (Edinburgh), K. Jahnke (MPIA), E. van Kampen (Innsbruck), J. Kenney (Yale), J. Knapen (Hertfordshire), S. Laine (CalTech/SIRTF), D. H. McIntosh (UMass), K. Meisenheimer (MPIA), B. Mobasher (STScI), C. Papovich (Arizona), C. Y. Peng (NRC-HIA), S. Ravindranath (STScI), H.-W. Rix (MPIA), I. Shlosman (Kentucky), R. Somerville (MPIA), N. Scoville (CalTech), A. Taylor (Edinburgh), L. Wisotzki (AIP), C. Wolf (Oxford), X. Zheng (PMO)
- *Graduate and Postdoctoral advisers* – Jeff Kenney and Richard Larson (Yale University), Nick Scoville (CalTech)
- *Thesis Adviser and postgraduate scholar sponsor – Postdocs:* Fabio Barazza (UT), Ingo Berentzen (Kentucky); *Graduate students:* Irina Marinova (UT), Amanda Heiderman (UT), Tim Weinzirl (UT); *Undergraduate students at UT:* Sarah. Miller, Kyle Penner, Steven Roloff, Kyle Lake, Elizabeth Hill-Aiello

SUMMARY PROPOSAL BUDGET

YEAR 1

ORGANIZATION **University of Texas at Austin**				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Shardha Jogee**				AWARD NO.		
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)	
1. **Shardha Jogee - P.I.**	0.00	0.00	0.50	$ 4,389	$	
2.						
3.						
4.						
5.						
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0		
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.50	4,389		
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)						
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0		
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0		
3. (2) GRADUATE STUDENTS				19,182		
4. (0) UNDERGRADUATE STUDENTS				0		
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0		
6. (1) OTHER				4,744		
TOTAL SALARIES AND WAGES (A + B)				28,315		
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				7,149		
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				35,464		
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)						
TOTAL EQUIPMENT				0		
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				2,830		
2. FOREIGN				1,640		
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 2,700 3. SUBSISTENCE 0 4. OTHER 0						
TOTAL NUMBER OF PARTICIPANTS (75) TOTAL PARTICIPANT COSTS				2,700		
G. OTHER DIRECT COSTS						
1. MATERIALS AND SUPPLIES				675		
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				4,400		
3. CONSULTANT SERVICES				1,084		
4. COMPUTER SERVICES				0		
5. SUBAWARDS				0		
6. OTHER				8,220		
TOTAL OTHER DIRECT COSTS				14,379		
H. TOTAL DIRECT COSTS (A THROUGH G)				57,013		
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Overhead (Rate: 50.0000, Base: 52903)**						
TOTAL INDIRECT COSTS (F&A)				26,452		
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				83,465		
K. RESIDUAL FUNDS				0		
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 83,465	$	
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $					
PI/PD NAME **Shardha Jogee**				FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*				Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 2

ORGANIZATION **University of Texas at Austin**				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Shardha Jogee**				AWARD NO.		
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)	
1. **Shardha Jogee - P.I.**	0.00	0.00	0.50	$ **4,521**	$	
2.						
3.						
4.						
5.						
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**		
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.50	**4,521**		
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)						
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**		
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**		
3. (**2**) GRADUATE STUDENTS				**19,758**		
4. (**0**) UNDERGRADUATE STUDENTS				**0**		
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**		
6. (**1**) OTHER				**4,982**		
TOTAL SALARIES AND WAGES (A + B)				**29,261**		
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**7,362**		
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**36,623**		
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)						
TOTAL EQUIPMENT				**0**		
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**2,830**		
2. FOREIGN				**1,640**		
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ **0** 2. TRAVEL **2,700** 3. SUBSISTENCE **0** 4. OTHER **0**						
TOTAL NUMBER OF PARTICIPANTS (**75**) TOTAL PARTICIPANT COSTS				**2,700**		
G. OTHER DIRECT COSTS						
1. MATERIALS AND SUPPLIES				**675**		
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**4,400**		
3. CONSULTANT SERVICES				**775**		
4. COMPUTER SERVICES				**0**		
5. SUBAWARDS				**0**		
6. OTHER				**8,466**		
TOTAL OTHER DIRECT COSTS				**14,316**		
H. TOTAL DIRECT COSTS (A THROUGH G)				**58,109**		
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Overhead (Rate: 50.0000, Base: 53875)**						
TOTAL INDIRECT COSTS (F&A)				**26,938**		
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**85,047**		
K. RESIDUAL FUNDS				**0**		
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **85,047**	$	
M. COST SHARING PROPOSED LEVEL $ **0**	AGREED LEVEL IF DIFFERENT $					
PI/PD NAME **Shardha Jogee**	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION					
ORG. REP. NAME*	Date Checked	Date Of Rate Sheet	Initials - ORG			

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET YEAR 3

ORGANIZATION **University of Texas at Austin**				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Shardha Jogee**				AWARD NO.		
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)	
1. Shardha Jogee - P.I.	0.00	0.00	1.50	$ 13,167	$	
2.						
3.						
4.						
5.						
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0		
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	1.50	13,167		
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)						
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0		
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0		
3. (1) GRADUATE STUDENTS				10,175		
4. (0) UNDERGRADUATE STUDENTS				0		
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0		
6. (1) OTHER				5,130		
TOTAL SALARIES AND WAGES (A + B)				28,472		
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				6,284		
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				34,756		
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)						
TOTAL EQUIPMENT				0		
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				2,830		
2. FOREIGN				1,640		
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 2,850 3. SUBSISTENCE 0 4. OTHER 0						
TOTAL NUMBER OF PARTICIPANTS (75) TOTAL PARTICIPANT COSTS				2,850		
G. OTHER DIRECT COSTS						
1. MATERIALS AND SUPPLIES				700		
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				4,400		
3. CONSULTANT SERVICES				464		
4. COMPUTER SERVICES				0		
5. SUBAWARDS				0		
6. OTHER				4,360		
TOTAL OTHER DIRECT COSTS				9,924		
H. TOTAL DIRECT COSTS (A THROUGH G)				52,000		
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) Overhead (Rate: 50.0000, Base: 47641)						
TOTAL INDIRECT COSTS (F&A)				23,821		
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				75,821		
K. RESIDUAL FUNDS				0		
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 75,821	$	
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $					
PI/PD NAME **Shardha Jogee**	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION					
ORG. REP. NAME*	Date Checked	Date Of Rate Sheet	Initials - ORG			

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY YEAR 4
PROPOSAL BUDGET

ORGANIZATION **University of Texas at Austin**	FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed / Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Shardha Jogee**	AWARD NO.	

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Shardha Jogee - P.I.**	0.00	0.00	1.50	$ **13,562**	$
2.					
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	1.50	**13,562**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**	
3. (**1**) GRADUATE STUDENTS				**10,480**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**1**) OTHER				**5,284**	
TOTAL SALARIES AND WAGES (A + B)				**29,326**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**6,473**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**35,799**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**2,830**	
2. FOREIGN				**1,640**	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ **0** 2. TRAVEL **2,850** 3. SUBSISTENCE **0** 4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**75**) TOTAL PARTICIPANT COSTS				**2,850**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**700**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**4,400**	
3. CONSULTANT SERVICES				**264**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**8,982**	
TOTAL OTHER DIRECT COSTS				**14,346**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**57,465**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Overhead (Rate: 50.0000, Base: 48483)**					
TOTAL INDIRECT COSTS (F&A)				**24,242**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**81,707**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **81,707**	$

M. COST SHARING PROPOSED LEVEL $ **0**	AGREED LEVEL IF DIFFERENT $
PI/PD NAME **Shardha Jogee**	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION
ORG. REP. NAME*	Date Checked / Date Of Rate Sheet / Initials - ORG

4 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

YEAR 5

ORGANIZATION **University of Texas at Austin**	FOR NSF USE ONLY PROPOSAL NO.	DURATION (months)		
		Proposed	Granted	
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Shardha Jogee**	AWARD NO.			

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Shardha Jogee - P.I.**	0.00	0.00	1.50	$ **13,969**	$
2.					
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	1.50	**13,969**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**	
3. (**1**) GRADUATE STUDENTS				**10,795**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**1**) OTHER				**5,443**	
TOTAL SALARIES AND WAGES (A + B)				**30,207**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**6,667**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**36,874**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**2,830**	
2. FOREIGN				**1,640**	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ **0** 2. TRAVEL **2,850** 3. SUBSISTENCE **0** 4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**75**) TOTAL PARTICIPANT COSTS				**2,850**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**700**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**4,400**	
3. CONSULTANT SERVICES				**58**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**9,251**	
TOTAL OTHER DIRECT COSTS				**14,409**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**58,603**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Overhead (Rate: 50.0000, Base: 49352)**					
TOTAL INDIRECT COSTS (F&A)				**24,676**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**83,279**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **83,279**	$

M. COST SHARING PROPOSED LEVEL $ **0**	AGREED LEVEL IF DIFFERENT $		
PI/PD NAME **Shardha Jogee**	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*	Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

Cumulative

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months)	
	Proposed	Granted
AWARD NO.		

ORGANIZATION
University of Texas at Austin

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Shardha Jogee

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Shardha Jogee - P.I.	0.00	0.00	5.50	$ 49,608	$
2.					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	5.50	49,608	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (7) GRADUATE STUDENTS				70,390	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (5) OTHER				25,583	
TOTAL SALARIES AND WAGES (A + B)				145,581	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				33,935	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				179,516	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				14,150	
2. FOREIGN				8,200	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 13,950 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (375) TOTAL PARTICIPANT COSTS				13,950	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				3,450	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				22,000	
3. CONSULTANT SERVICES				2,645	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				39,279	
TOTAL OTHER DIRECT COSTS				67,374	
H. TOTAL DIRECT COSTS (A THROUGH G)				283,190	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				126,129	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				409,319	
K. RESIDUAL FUNDS				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 409,319	$

M. COST SHARING PROPOSED LEVEL $ 0 AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Shardha Jogee

ORG. REP. NAME*

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C ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

CURRENT AND PENDING SUPPORT FOR PI (Shardha Jogee)

There is no pending proposal for the PI. Below is the listing of the current support.

(1) NASA/LTSA NAG5-13063 (PI)

Title: Structure and Dynamics of Local and Intermediate Redshift Disks

Type of support: Current

Investigators: Shardha Jogee (PI) and Isaac Shlosman (Co-I)

Source of Support: NASA

Project Location: University of Texas (UT) at Austin and University of Kentucky

Total Award Amount: $558,539

Starting date and Ending Date: 03/17/2003 to 03/17/2008 (now extended to 1/14/2010)

Person-months per year committed to the project:

a) Graduate students (3) : Cal:0.0, Acad:4.5, Summer:2.5
b) Postdoctoral fellows: Cal:0.0, Acad:6.0, Summer:0.0
c) PI (Jogee): Cal:0.0, Acad:0.0, Summer:0.8
d) Co-I (Shlosman): Cal:0.0, Acad:0.0, Summer:1.0

(2) NSF AST-0607748 (PI)

Title: Bars and their Impact on Galaxy Evolution over the Last Eight Billion Years

Type of support: Current

Investigator: Shardha Jogee (PI)

Source of Support: NSF

Project Location: University of Texas (UT) at Austin

Total Award Amount: $311,748

Starting date and Ending Date: 09/1/2006 to 09/1/2009

Person-months per year committed to the project:

a) Graduate student (Marinova): Cal:0.0, Acad:4.5, Summer:1.0
b) PI (Jogee): Cal:0.0, Acad:0.0, Summer:1.0

(3) HST GO-10861 (Co-I)

Title: An ACS Treasury Survey of the Coma Cluster

Type of support: Current

Investigator: Shardha Jogee (Co-I)

Source of Support: NASA

Project Location: University of Texas (UT) at Austin

Total Award Amount: $57,105

Starting date and Ending Date: 08/1/2006 to 08/1/2008

Person-months per year committed to the project:

a) Graduate student (Weinzirl): Cal:0.0, Acad:1.25, Summer:0.5
b) Graduate student (Heiderman): Cal:0.0, Acad:1.25, Summer:0.5
c) Co-I (Jogee): Cal:0.0, Acad:0.0, Summer:0.3

(4) HST GO-11082 (Co-I)

Title: NICMOS Imaging of GOODS

Type of support: Current

Investigator: Shardha Jogee (Co-I)

Source of Support: NASA

Project Location: University of Texas (UT) at Austin

Total Award Amount: $68,268

Starting date and Ending Date: 10/1/2007 to 09/30/2009

Person-months per year committed to the project:

a) Graduate student (Weinzirl): Cal:0.0, Acad:1.25, Summer:0.5
b) Graduate student (Heiderman): Cal:0.0, Acad:1.25, Summer:0.5
c) Co-I (Jogee): Cal:0.0, Acad:0.0, Summer:0.25

(5) NSF Undergraduate STEM proposal DUE-0807140 (Co-I)

Title: Scientists for Tomorrow

Type of support: Current

Investigator: J. S. Moore (PI), Shardha Jogee (Co-I), and 3 other UT co-investigators

Source of Support: NSF

Project Location: University of Texas (UT) at Austin

Total Award Amount: $600,000

Starting date and Ending Date: 09/1/2008 to 08/31/2013

Person-months per year committed to the project:

a) Co-I (Jogee): Cal:0.0, Acad:1.0 (unfunded), Summer:0.0

(6) NASA Education and Public Outreach award HST-EO-10861.35-A (PI)

Title: A Cluster of Activities on Coma from the Hubble Space Telescope, StarDate, and McDonald Observatory

Type of support: Current

Investigators: Shardha Jogee (PI) and EPO team at UT Austin

Source of Support: NASA

Project Location: University of Texas (UT) at Austin

Total Award Amount: $50,000

Starting date and Ending Date: 04/1/2007 to 03/31/2009

Person-months per year committed to the project:
a) EPO team members: Cal:3.0 Acad:0.0 Summer:0.0
b) PI (Jogee): Cal:0.0, Acad:1.0 (unfunded), Summer:0.0

(7) NASA Education and Public Outreach award NASA NNG 06GB99G (PI)

Title: Building a Bridge to Texas High School Science Teachers and Students

Type of support: Current

Investigators: Shardha Jogee (PI) and EPO team at UT Austin

Source of Support: NASA

Project Location: University of Texas (UT) at Austin

Total Award Amount: $45,000

Starting date and Ending Date: 04/1/2006 to 03/31/2008

Person-months per year committed to the project:
a) EPO team members: Cal:3.0 Acad:0.0 Summer:0.0
b) PI (Jogee): Cal:0.0, Acad:1.0 (unfunded), Summer:0.0