Submitted: January 31, 2003 Proposal No.: __________
Trimester: 2003-2

Submit: 8 paper copies to
Director's Office
McDonald Observatory
University of Texas at Austin
Austin, TX 78712-1083 U.S.A.

McDONALD OBSERVATORY
UNIVERSITY OF TEXAS AT AUSTIN
OBSERVING TIME REQUEST
January 2002

A LaTeX form and style file may
be obtained from FTP site:
//astro.as.utexas.edu/pub/mcdonald/
and returned when completed to:
obs-time-request@astro.as.utexas.edu

Proposal Title: Luminous Blue Compact Galaxies: Galaxy Evolution Templates

PI & Investigator Institution: Dr. Michael N. Fanelli, University of North Texas

PI E-Mail Address: fanelli@unt.edu

Mail Address for non-UT PIs: Dept. of Physics, University of North Texas, Denton, TX, 76203

Co-I & Institution: Dr. Pamela M. Marcum, Texas Christian University

Co-I & Institution: Heather Appleby, University of North Texas

Abstract

We propose to continue an optical imaging survey of a well-defined sample of luminous blue compact galaxies (LBCGs). These objects are extragalactic systems undergoing intense star formation episodes, and appear to be close analogs in the local universe ($z < 0.05$) to young galaxies at high redshift. This survey is one component within a multiwavelength campaign to assess the nature and evolutionary state of LBCGs. Our objectives are: (1) characterize their physical structures, stellar content, and star formation histories, and (2), determine the degree to which interactions with companions are responsible for their global evolution. We will develop a two-parameter interaction 'index', as a framework for exploring the importance of interaction-induced starburst activity in galaxies. The properties of LBCGs can be compared to star-forming systems at all redshifts, to provide insight on the evolution of the galaxy population over cosmic time.

We with to obtain to obtain imagery of this sample using the White Guider on the 2.1m in optical broad-band and narrow-band Hα filters.

Observing Request Summary

Total Nights Requested:	5
Telescope and Observing Mode:	2.1-m f/13.5
Instrument Requested:	White Guider + TK4
Specific Dates Requested (list):	

Special Constraints (Must Be Justified in the Proposal Text)

Time Critical Observations:	no
Target of Opportunity Observations:	no
Lunar Constraints:	new +/- 7
Other Constraints (Dates you cannot observe):	Cannot observe May 6-11 (class schedule)

Scientific Justification

Blue compact galaxies are systems in which high levels of massive star formation are presently occurring (2-20 $M_\odot$ yr^{-1}), based on their blue colors and UV/optical spectra. These spectra show emission lines indicative of photoionization from massive OB stars (e.g., Papaderos etal 1996, Kong & Cheng 1999). Star formation in blue compacts proceeds in "bursts", 10^6 to 10^8 years in duration, based on constraints imposed by the observed gas content available for star formation. Blue compacts are observed over a range in total luminosities, from dwarfs systems to the exceptional luminous blue compacts (LBCGs), with absolute magnitudes brighter than $M_B \sim -21$. It is the *scale* of star formation which distinguishes the luminous blue compacts. The integrated luminosity of the more extreme LBCGs suggests that 10^5 to several 10^6 massive stars have formed within the past 10-20 Myr. While the photometric and morphological properties of blue compacts *dwarfs* are also interpreted in terms of starbursts, the massive star content in the dwarf compacts is on the order of 10s to a few 10^3 OB stars, 2-4 orders of magnitude less in scale than the LBCGs.

The current paradigm for the evolution of the galaxy population posits that star formation peaked early in cosmic time, with formation rates (SFRs) declining during the last several billion years. Due to the scale of observed star formation, LBCGs are likely the best analogs in the nearby universe to the early evolution phases of most normal galaxies, when their SFRs were much higher than at present. The importance of *nearby* LBCGs derives from the ability to explore these systems at many wavelengths with excellent spatial and spectral resolution, unlike extremely distant galaxies, which are faint and subtend a few arcseconds, requiring substantial integration times with 4-10m class telescopes.

A paradox concerning LBCGs is their optical colors, i.e., their "blueness". Another class of extreme star-forming systems, the ultraluminous infrared galaxies (ULIGs), are also believed to be undergoing intense star formation, with rates of 5-100 $M_\odot$ yr^{-1}. However in the ULIGs, the recently-formed stars are heavily obscured ($\tau_V >> 1$) by dust, and exhibit red global optical colors. LBCGs are both powerful star formation engines, emit substantial FIR radiation, yet are not heavily obscured, as evidenced by their blue UV/optical colors. This low obscuration along some lines of sight permits *direct* detection of the starburst populations, given sufficient spatial resolution.

We have undertaken an optical imaging survey of ~100 LBCs, as one element in a multiwavelength investigation. A representative sample has been compiled from existing surveys for extragalactic emission line sources (e.g., Gordon & Gottesman 1981, Thuan & Martin 1981). Analysis of these images will provide insight on their structural and photometric properties, quantify the rate and distribution of recently-formed stars, and, most importantly, assess the degree to which these systems are interacting with nearby galaxies. A common assumption is that most global starbursts are triggered by dynamical perturbations induced by companion systems. HST observations of the more distant ultraluminous infrared galaxies (Borne etal. 2000) suggests that multiple interactions/mergers account for their starburst episodes. We will test this model by developing a two-parameter interaction index, based on presence of companions to the LBCs, their angular separations and the primary/companion luminosity ratio. Are interactions the dominant mechanism for triggering starburst episodes in LBCGs ?

Our analytical approach: (1) Using image analysis software (coded in IDL) developed for our UV imaging program (Marcum etal 2001), we will charcterize the morphology of the LBCGs, search for companions, and perform point- and extended source photometry, producing radial light and color profiles, color maps, total magnitudes and colors. (2) Observed radial light and color profiles will be interpreted using the techniques of stellar population synthesis (Cornett etal. 1994, Fanelli etal. 1997) to explore the star formation histories of these systems. (3) We will derive the total radiative and kinetic luminosities of starburst knots using model predictions (Leitherer etal 1999). These quantities can then be correlated with the morphology of the ionized gas associated with the starburst knots.

The science proposed here is one element of a project awarded funding in the 2001 Texas Advanced Research Program. This TARP project is entitled "Galaxy Evolution Templates".

References

Borne, K., Bushouse, H., Lucas, R.A., & Colina, L. 2000, ApJL, 529, L77.

Cornett, R.W., etal. 1994, ApJ, 426, 553

Fanelli, M.N., etal. 1997a, ApJ, 481, 735

Gordon, D. & Gottesman, S.T. 1981, AJ 86, 161

Kong, X., & Cheng, F.Z. 1999, A&A 351, 477

Leitherer, C., etal. 1999, ApJS, 123, 3

Marcum, P.M., etal. 2001, ApJS, 132, 129

Papaderos, P., Loose, H.-H, Thuan, T.X., & Fricke, K.J. 1996, A&AS 120, 207

Thuan, T.X., & Martin, G.E. 1981, ApJ, 247, 823

Description of Observations & Justification of Exposure Times

Instrument
The White Guider using the TK4 CCD provides the appropriate imaging system for this project.

Filters:
Broad-band imaging through UBVRI filters will be used to provide differential and integrated photometry. We will also use Hα filters optimized to the redshift distribution of our sample.

Exposure Times:
Integrated blue magnitudes for objects in this sample range from 13.5 to 16.5 with D_{25} diameters on average subtending 1 arcminute. For each object we anticipate ~1 hour exposure time for the broad-band images: 600s for BVR, 300s for I, 1200s for U, and typically an hour on-source for Hα (3, 20-min exposures). For a 10-hour night during the April-July period, we can image 4-5 objects per night.

Number of Nights:
Our final sample will contain about 100 LBCGs more luminous than $M_B < -19.0$. We received 5 nights for this program during the 2002-2 trimester: 03-07 July 2002. The weather constrained us to about 0.5 nights of decent imaging. We received 6 nights during the 2003-1 trimester: Dec 27 - Jan 01. The weather was more cooperative, resulting in about 4 useful nights. We concentrated on UBVRI imaging and obtained data on about 15 objects.

We have asked to use the 2.1m because it is sufficient to obtain deep broad-band images of our sources. We remain concerned about the long exposures needed for Hα imaging coupled with the tracking/guiding issues on the 2.1m experienced on previous runs by Marcum. We attempted to assess the capabilities for Hα imaging during the winter 2002 run, including attempting to rig our own SBIG CCD to the 2.1m finder for off-axis guiding. Since we choose to use the good weather to take a larger dataset of broad-band imagery, we did not reach a conclusion re Hα. We will further explore this issue if awarded time.

Objects listed in the table are representative of the survey sample. Targets exist at most right ascensions. The last column list the blue magnitude and observed heliocentric redshift for each source.

Object Table

Object Name	RA (hh:mm)	Dec (±dd:mm)	m(B) mags	cz km/sec
Haro 15	00:48:35	−12:43	13.46	6407
NGC 2415	07:36:56	+35:14	12.78	3784
Haro 25	10:48:44	+26:02	15.0	7630
Haro 32	12:43:48	+54:54	14.1	4942
Haro 34	12:45:07	+21:10	15.1	6697
Mrk 235	13:00:02	+33:26	14.7	7252
Mrk 685	14:31:09	+27:14	15.5	4464
II Zw 185	22:41:25	+23:22	13.94	7144

Description and Justification of Special Constraints

(1) Dark time requested to maximize sensitivity to faint, extended emission in the source sample.

(2) Both Fanelli and Marcum must be on campus during the week of May 4-11 to administer final exams for their classes.

Results from Previous Observing Time at McDonald Observatory

We have submitted this proposal for the 2002-2 trimester and received 5 nights, for the 2003-1 trimester, 6 nights. Fanelli and Marcum have been involved in two projects which have received substantial time at McDonald during the past three years.

(1) "The Nature and Evolutionary Status of Isolated Elliptical Galaxies".
Dissertation project for Christian Aars, a student at TCU. Imaging data was obtained on the 0.8m and 2.1m, optical spectra obtained on the 2.7m. Aars defended this thesis and graduated in August 2002. The 0.8m data was presented in "A Study of the Projected Galaxy Density around Nine Isolated Elliptical Galaxies", Aars, Marcum, and Fanelli, Astronomical Journal 122, 2923 (2001). The 2.1m imaging data has been reduced and interpreted. A paper is nearing completion for submission to AJ. The 2.7m spectral data has been reduced, and we are continuing the analysis.

(2) "A Near-Infrared Library of Stellar Spectra", NSF-funded project, with Marcum as PI. Four runs on the 2.7m using COOLSPEC: Mar 2000, Oct 2000, May 2001, Nov 2001. Data from the first three runs has been reduced, work in is progress on the data from the Nov 2001 run, which lasted 11 nights.

Users of McDonald Observatory telescopes and instrumentation must demonstrate knowledge and proficiency in their use. ***All proposers MUST fill in the following:***

Name(s) of Actual Observer(s): M. Fanelli, H. Appleby, P. Marcum

E-Mail Address of Observer(s): fanelli@unt.edu, p.marcum@tcu.edu

Telescope/date last used: 2.1m, 12/27/02 to 01/01/03

Instrument/date last used: WHT Guider, 12/27/02 to 01/01/03

If the actual osberver is not a qualified user of this instrumentation, you are required to select one of the following training options for the actual observer to become a qualified user:

___ 1. I have arranged for a University of Texas observer experienced with this instrument to accompany the actual observer for at least 2 nights. Name: ____________________

___ 2. I have arranged to hire a University of Texas graduate student experienced with this instrument to accompany the actual observer. Name: ____________________

___ 3. I agree to attend at least 2 nights of an observing run which is prior to the requested run in order to become familiar with the telescope/instrument.
Are you willing to make a special trip to learn the instrument? Yes ___ No ___

New Users of McDonald Telescopes are required to provide the following information:

Previous Observing Experience:

Name of Reference and E-Mail address: ____________________

Initial Request for Services:

Telescope, auxiliary equipment, and software requirements. Detail the instrument set-up required for this proposal. *Be very specific, as this is the page the mountain staff will use to set up your instrument. A final-revised RFS including housing requirements is due at the Observatory at least 3 weeks prior to your scheduled observing time.*

Instrument Requested: White Guider

Detector: TK4

CCD Binning: 2x2

Gratings: none

Filters: UBVRI set + narrow-band Hα filters.

Software Requirements: IRAF

Other Special Requests: ____________________

Justification for Special Telescope Operator:

Additional Information to be Provided by
All Graduate Students

Name of Graduate Student: Heather Appleby

Student's Institution: University of North Texas

Title of Dissertation: Results of this project will form the basis for a master's thesis.

Name of Advisor: Dr. Mike Fanelli

Year as Graduate Student: 2

Expected Year of Completion of Ph.D: N/A

Date of Advancement to Ph.D. Candidacy: N/A

Research part of degree requirements? : The research is optional.

Previous Observing Experience:

Participated in July 02 2.1m run, 5 nights and Dec 02, 2.1m run, 6 nights.

Estimated Telescope Time Required for this Project or Dissertation:

This project is a component of the PI's Texas Advanced Research Project Grant, awarded in the 2001 cycle. We estimate that 4 to 5 observing runs, lasting 5 nights will be required, weather permitting, spaced over 4-6 trimesters. Not all of the data will be needed to for the student to complete a master's project.