OBSERVING REQUEST
University of Arizona Observatories

Year: *2004* **Term:** *Jan - Apr* **Proposal Number:**

The Reddening and Metallicity of HIZSS 3, a Neighboring Dwarf Irregular Galaxy Hidden by the Milky Way

PI: Phil Massey, Lowell Obs.

CoI(s): Kathleen DeGioia-Eastwood, Dept. Phys.& Astron., NAU

Proposal Type: short-term

Abstract of Scientific Justification
HIZSS 3 is a newly found dwarf irregular (dIr) galaxy that lies in the "Zone of Avoidance" (ZOA) caused by the disk of the Milky Way. First identified in a 21-cm survey by Henning et al. (2000), new data obtained at the VLA and in the optical (Hα) has shown that it is very nearby (Massey, Henning, & Kraan-Korteweg 2003), possibly even in the Local Group. As part of our campaign to characterize this newly found neighbor, we are asking for MMT time to determine its reddening and metallicity using spectrophotometry of its one identified H II region. The large aperture of the MMT is needed, as E(B-V) is quite large owing to the galaxy's location near the Galactic plane.

Summary of observing runs requested for this project

Run	Telescope	Instrument	No. Nights	Moon	Cage	Optimal months	Accept. months
1	MMT	Blue	1	dark		Jan-Feb	Jan-Mar
2							
3							
4							

Scheduling constraints and non-usable dates *(up to two lines).*

See below.

Is sharing nights possible and/or advisable?

Given the object's equatorial location, there are only 4 hours per night when the object is at an airmass < 1.5. So, an optimal use of time would be to have two FIRST halves during Feb dark (or LAST quarter) time. (The parallactic angle is also closer to the PA of the HII region during the first half of the night.) Second choice would be a WHOLE (dark) night during Jan, and we would fill in from other projects.

Approval for Instrument Use from PI? N/A

For MMT requests only: Percentage of time to be assigned to UAO and CfA 100, 0

Observing List (attach list if longer than 10 objects)

Object	RA	DEC	Magniude
HIZSS 3	07:00	-04:00	N/A

CONTACT INFORMATION:

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GRADUATE STUDENTS:

Whose second year project is this? ______________________________

Whose thesis is this? ____

For **each** graduate student named on the front page, provide the following information:

Student's Name	Advisor's Name	Advisor's Signature

Scientific Justification

A complete census of nearby galaxies is hampered by the presence of our own Milky Way, which creates a "zone of avoidance" (ZOA) in the distribution of galaxies on the plane of the sky. Yet an accurate knowledge of the mass distribution in our neighborhood is essential if we are to understand the dynamical evolution of the Local Group from kinematic studies (Peebles et al. 2001). In addition, the discovery of previously unknown nearby galaxies will further efforts to understand the local velocity field (Kraan-Korteweg 1986, Karachentsev et al. 2002), as well as providing additional locales for studying the resolved stellar content of nearby systems (cf. Mateo 1998, Massey 2003).

The object HIZSS 3 was found as part of an ongoing 21-cm search for nearby galaxies in the ZOA by Henning et al. (2000), and was further studied with the VLA and optical imaging by Massey, Henning, & Kraan-Korteweg (2003). Its 21-cm velocity width (at 20% peak intensity) is 90 km $\sec^{-1}$, typical of a dwarf irregular galaxy. The remarkable thing about this source, however, is its low heliocentric velocity, 299 km s^{-1}. Given its location relative to the solar apex, this would translate to a velocity with respect to the Local Group centroid of 134 km s^{-1}. If the galaxy has no peculiar velocity, then this implies a distance of 1.8 Mpc ($H_o = 75$ km $\sec^{-1}$ Mpc^{-1}), but as Massey et al. (2003) note, several Milky Way satellites (Leo I, Sag, Sculptor) have similar velocities with respect to the Local Group centroid. Massey et al. (2003) conclude that the galaxy is an unlikely, but possible, Local Group member.

Massey et al. (2003)'s optical imaging failed to detect a resolved stellar population, doubtless due to the high extinction at the object's low galactic latitude ($b = 0.09°$). However, their Hα imaging did detect a single H II region (Fig. 1), and follow-up spectroscopy with the KPNO 2.1-m detected the Hα line, and demonstrated that its velocity matched that of the radio source, confirming that HIZSS 3 must have some current star formation.

We are proposing here to obtain spectrophotometry of the H II region to address two key issues in characterizing this newly found neighbor. First, by measuring the relative flux in Hα and Hβ and comparing with what is expected from recombination theory we can obtain an accurate measurement of the reddening. This is needed before we can use any method to obtain an accurate distance. Secondly,we can obtain the oxygen abundance of the H II region by measuring [OII]λ3727 and [OIII]λ5007 and applying the R_{23} relation (Pagel et al. 1979), with the [OIII] λ5007/[NII] λ6584 ratio being used to remove the degeneracy in the classic R_{23} method (McGaugh 1991, Edmunds & Pagel 1984; see also Hunter & Hoffman 1999). This gives us an important characterization of the current evolutionary status of the galaxy in that the oxygen abundance tells us how much processing of interstellar material has taken place. As detailed below, we expect this to be practical with several hours of exposure with the MMT.

These optical data will provide a vital complement to radio and NIR data that we are also obtaining in collaboration with Trish Henning (UNM) and Dave Silva (ESO). Indeed, we have just been granted "Category A" queue time on the ESO 8.2-m VLT to obtain NIR imaging of HIZSS 3. These data will be obtained in the next few months, barring some catastrophe, and should go deep enough to construct a color-magnitude diagram that just reaches the tip of the red giant branch (trgb). We plan to use this as the basis for a Cycle 13 HST NICMOS proposal to use the trgb for a solid distance determination. The observations we propose here with the MMT to determine the extinction and metallicity are a crucial component of characterizing this object. For one thing, even in the K-band a knowledge of the reddening is needed, as $A_K/E(B-V) = 0.4$. More importantly, these NIR data will provide only a snapshot of the intermediate-age population. A knowledge of the metallicity tells us how much processing has occurred over the life of the galaxy.

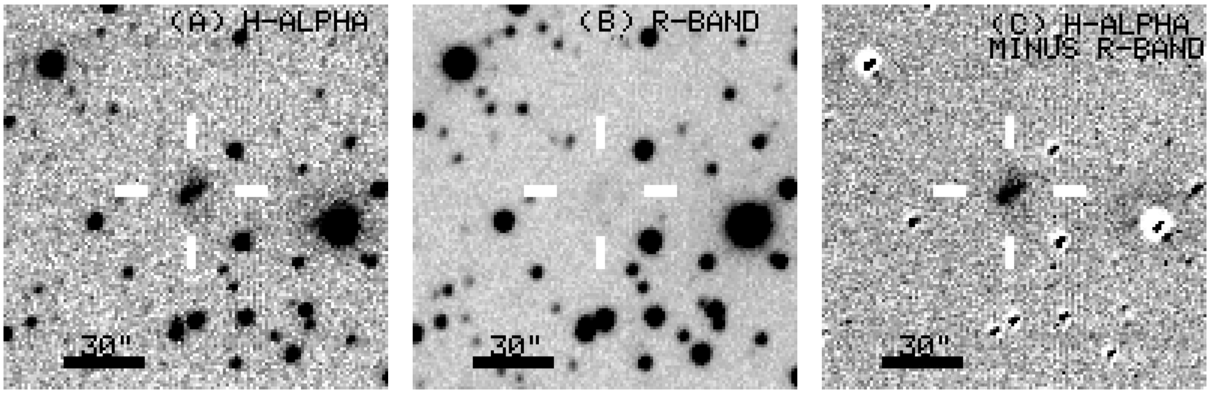

Figure 1: The H II region found in HIZSS 3. In (a) we show the Hα image taken through a 30Å wide interference filter obtained on the Lowell 1.1-m. The H II region is the extended feature in mid-frame. In (b) we show the continuum R-band exposure. The H II region is faintly visible as the R bandpass includes the Hα line. In (c) we show the Hα exposure with the continuum removed. Differences in the point-spread-function lead to the over- and under-subtracted images for the brighter stars. In all three images, north is up and east is the left. From Massey et al. (2003).

References

Edmunds, M. G., & Pagel, B. E. J. 1984, MNRAS, 211, 507

Henning, P. A. et al. 2000, AJ, 119, 2686

Karachentsev, I. D. et al. 2002, A&A, 389, 812

Kraan-Korteweg, R. C. 1986, A&A 389, 812

Hunter, D., A., & Hoffman, L. 1999, AJ, 117, 2789

Massey, P. 2003, ARA&A, 41, 15

Massey, P., Henning, P. A., & Kraan-Korteweg, R. C. 2003, AJ, 126, in press (astro-ph/0308080)

Mateo, M. 1998, ARA&A, 36, 435

McGaugh, S. S. 1991, ApJ, 380, 140

Pagel, B. E. J. et al. 1979, MNRAS, 189, 95

Peebles, P. J. E. et al. 2001, ApJ, 554, 104

Experimental Design & Technical Description *Describe your overall observational program. How will these observations contribute toward the accomplishment of the goals outlined in the science justification? If you've requested long-term status, justify why this is necessary for successful completion of the science. (limit text to one page)*

Our immediate goals are to (a) determine the reddening from the relative flux of Hβ and Hα, and (b) determine the metallicity by measuring the flux at [OII]λ3727 and [OIII]λ5007. For this we estimate that we will need two half nights with the mighty MMT and blue channel as follows.

The greatest uncertainty in estimating our exposure times is our lack of knowledge of the reddening. We expect that the reddening is quite high given the galaxy's low galactic latitude ($b = 0.09°$); Henning et al. (2000) estimate E(B-V)=1.1 mag based upon the DIRBE/*IRAS* extinction maps (Schlegel et al. 1998, ApJ, 500, 525), although this procedure is quite uncertain for $b < 5°$. We adopt E(B-V)=1.1 mag as a "best guess", but also consider what would happen if E(B-V)=2.2 mag. Higher extinction than that is unlikely as it would lead to an unusually high luminosity for the first-ranked H II region, assuming an (admittedly uncertain!) distance of 1.8 Mpc.

(a) **Hβ to Hα ratio.** Massey et al. (2003) measured the Hα flux as 2.2×10^{-14} ergs cm^{-2} s^{-1} distributed over the 4" by 12" H II region. If there was no reddening Hβ would have a flux 1/2.86 times this value (Case B, T$_e$=10,000°, $N_e = 100$ cm^{-3}), or 7.7×10^{-15} ergs cm^{-2} s^{-1}.

If E(B-V)=1.1 mag, then the *additional* extinction of Hβ relative to Hα is 1.2 mag (Cardelli, Clayton, & Mathis 1989, ApJ, 345, 245), and we can expect the observed flux to be 2.6×10^{-15} ergs cm^{-2} s^{-1}. If the extinction is double that, then the expected flux at Hβ will be 8.7×10^{-16} ergs cm^{-2} s^{-1}. According to the sensitivity curves for grating 500, we would achieve 700 counts/sec/Å at Hβ for a spectrophotometric "AB" mag =11.5 (i.e., $F_\lambda = 1.2 \times 10^{-13}$ ergs s^{-1} cm^{-2} Å^{-1} at Hβ). Thus we estimate that we will obtain a count rate of 5 to 15 e/sec integrated over the line. In practice, with a 2" slit at the parallactic angle, we'll achieve only a fraction (one-third, on average) of this count rate, but still we will require only 10 minutes or so to achieve a S/N of 30.

(b) **Metallicity.** The real challenge will be pulling [OII]λ3727 out of the muck of the Galactic plane. The extinction here will be 2.5 mag greater than at Hα if E(B-V)=1.1 mag, or 5.0 mag if E(B-V)=2.2 mag. An additional uncertainty is the intrinsic ratio of [OII]λ3727 to Hα, but we can estimate this from the ratios observed in similar dwarf irregular galaxies (Hunter & Hoffman 1999, AJ, 117, 2786). The *de-reddened* ratios [OII] λ3727/Hα range from 0.01 to 2.8, with a *median* value of 0.3. More to the point, we think, is that 90% of the regions with *measured* [OII] λ3727 have a ratio [OII]λ3727/H$\alpha \geq 0.04$. So, if E(B-V)=1.1 mag, we can *reasonably* expect an observed flux of at least 8.8×10^{-17} ergs cm^{-2} s^{-1}, and a count rate (based on the Web's throughput numbers) of 0.1 e/sec integrated over the line, where we again have assumed that one-third of the flux makes it through the slit, on average. To reach a S/N of 30 we require 9000 sec of integration or about 2.5 hours. If the extinction is 10 times higher than that we can hope to achieve a S/N of 15 in 6+ hours of integration. A moon-less sky is needed, as the sky brightness goes up rapidly at λ3700 with even a little bit of moon.

Thus we conclude that a single night (preferably 2x0.5 nights) on the MMT has a very good chance of giving us a solid [OII]λ3727 measurement.

We plan to use the 500 line/mm grating; we substantiated in September that this will allow us to cover the full wavelength range from [OII]λ3727 to Hα and even beyond to [SII]$\lambda\lambda$6717, 31 with a comfortable margin on either side to provide coverage of the spectrophotometric standard bandpasses at 3700 and 6750. The 2" slit will provide a spectral resolution of 7.2Å, more than adequate to safely separate Hα from the neighboring [NII]λ6584 line. (The next largest slit, 3.5", would allow in more light but at 13Å resolution [NII] would begin to blend with Hα.)

Previous Use of Steward Facilities *List allocations of telescope time on facilities available through Steward to the investigators during the past 2 years, together with the current status of the data (cite publications where appropriate). Mark with an asterisk those allocations of time related to the current proposal.*

Massey & Holmes 2002, ApJ, 580, L35. Based upon one half-night of MMT data obtained in September 2002.