The MCELS Data Reduction Pipeline and Its Application to PNe Searches in the LMC

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The Magellanic Cloud Emission-Line Survey (MCELS) obtained observations toward the Large and Small Magellanic Clouds (LMC and SMC, respectively) over six years using the UM/CTIO Curtis Schmidt telescope to produce deep images in [O III], H-alpha, and [S II] emission-lines, in addition to adjacent green and red continuum filters. This survey covered the central 8°x8° of the LMC and the central 3.5°x4.5° of the SMC and encompasses most of the gaseous extent of each galaxy with an angular resolution of ~5 arcsec or better, allowing us to identify and study interstellar structures on ~ 1-1000 pc physical scales.
We have modified the SuperMACHO/Essence-*w* pipeline, developed for Blanco 4m Mosaic II data, to reduce MCELS data in a uniform manner. In addition to basic reductions (e.g., bias-subtraction, flat-fielding, etc), this pipeline uses spatially-varying convolution kernels to match the PSFs of the narrow-band and broad-band images and produce continuum-subtracted images for the narrow-band filters. We use flux measurements of previously identified planetary nebulae (PNe) in the LMC, e.g. Reid & Parker (2010), and photometry obtained by our pipeline to create color-magnitude and color-color diagrams in the MCELS filters to search for new PNe candidates in the LMC.

Introduction:

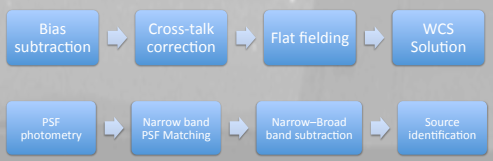
The MCELS project was designed to obtain a deep and uniform dataset to measure the physical properties of ionized interstellar structures in the Large and Small Magellanic Clouds (MCs). This survey can be used to investigate the ionized gas structures of wind-blown bubbles, HII regions, planetary nebulae (PNe), supernova remnants (SNRs), superbubbles, and supergiant shells. The MCs are the ideal laboratories in which to study the morphology and physical characteristics of the ISM due to their known distances and low foreground extinction.

Data Acquisition and Coverage:

- UM/CTIO Curtis Schmidt Telescope
- SiTE 2048x2048 CCD Detector
- 2.3"/pixel (~5" resolution)
- Field-of-View: 1.3° × 1.3°
- [OIII] 5012/40, Green-continuum 5130/155, Hα 6568/28, [SII] 6729/50, and Red-continuum 6850/100 filters

Figure 1: The N 206 HII region (LHA 120-N 206; Henize 1956) as seen by MCELS. *(Top)*: [OIII] – blue, [SII] – green, Hα – red. *(Bottom)*: Continuum-subtracted [OIII] – blue, [SII] – green, Hα – red.

Data Reduction:



References:

- Smith R. C., Points S. D., Chu Y.-H., Winkler P. F., MCELS Team. 2005, AAS, 207, 2507S.
- Damke G., Points S. D., Smith R. C., Rest A., MCELS Team. 2007, AAS, 2111,006D.
- Reid Warren A., Parker Quentin A., 2010, MNRAS, 405, 1349R.
- McMillan R., Ciardullo R., Jacoby G. H., 1993, AJ, 416, 62.

Planetary Nebulae Detection:

- Planetary Nebulae (PNe are a common end-point of stellar evolution, becoming observable towards the end of lifetimes of a large fraction of stars between 1-8 solar masses and lasting 30 000-70 000 years.
- In optical bands PNe show numerous emission lines, being [OIII] 5007 the strongest one followed by [OIII] 4959 and Ha, but they essentially don't exhibit a large fraction of continuum flux.
- The detection is made using difference imaging between [OIII] and Green-continuum and Hα and Red-continuum, where we identify point and extended sources using DoPhot.
- Conditions for PNe candidates:
  - Detected point sources in the narrow-band images that have no resolved counterpart in the continuum band,
  - Sources with flux ratio Hα/[OIII] < 1 allowing us to differentiate from a HII compact region.
- Our test field:

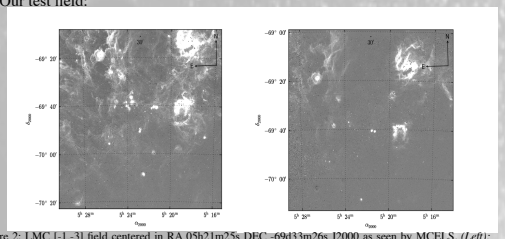


Figure 2: LMC [-1,-3] field centered in RA 05h21m25s DEC -69d33m26s J2000 as seen by MCELS. *(Left)*: Hα Continuum-subtracted. *(Right)*: Continuum-subtracted [OIII]

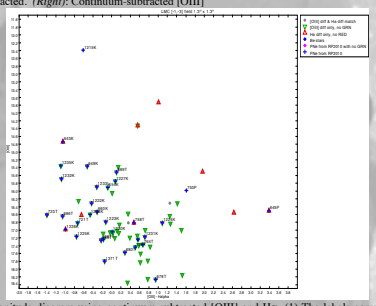


Figure 3: Color Magnitude diagram using continuum subtracted [OIII] and Hα. (1) The labels correspond to PNe cataloged by Reid and Parker 2010 (RP2010) as **K**: previously known, **T**: truly-likely, **L**: likely and **P**: possible. (2) We recovered 31 of 62 PNe from RP2010 in this field. (3) Only 2 of the 31 we recovered has continuum resolved counterpart. (4) 70% of RP2010 PNe are brighter in [OIII] than Hα, giving us a good way to separate PNe from objects like HII compact regions, YSO, among others. (5) Our best candidates should be towards the top-left part of the diagram.

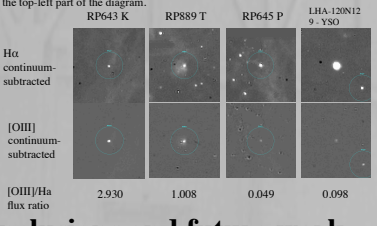


Figure 4: Examples of detections from the pipeline in LMC [-1,-3]

Conclusions and future work:

- In this on-going project, we are probing the power of difference imaging algorithms through the pipeline by detecting PNe and others emission line objects.
- We have used photometry on continuum-subtracted fields to detect objects which lack of continuum flux, allowing us to found new candidates or/and re-classify previous ones.
- In the future, we will expand the search to all fields covered in LMC and SMC, refining our methods in order to define our candidates for spectroscopic follow-up.

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