SONYC: Sub-stellar Objects in Nearby Young Clusters

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**Motivation**

The origin of the lowest mass free-floating objects, i.e. brown dwarfs (BDs) and planetary mass objects, is one of the major unsolved questions in star formation. Various competing origin theories exist, such as turbulent fragmentation, dynamical decay of mini-clusters, and ejection from proto-planetary disks. These theories are increasingly capable of providing predictions for the frequency and properties of sub-stellar objects.

A fundamental prerequisite to test these theories is to establish a census of young brown dwarfs, allowing us to probe the initial mass function, binary statistics, and properties of accretion disks. SONYC is an ongoing survey since 2007 to provide a sub-stellar population census in nearby star forming regions. We present here the survey with its major findings, and encourage the use of survey catalogs and spectra, available at browndwarfs.org/sonyc

**SONYC Survey**

Identification of sub-stellar candidates through wide-field, deep optical and near-infrared imaging campaigns, archival photometry, and proper motions.

Candidate verification through extensive follow-up spectroscopy.

| NGC1333 | Rho Oph | Lupus 3 | Chi 1 | Up Sco |
|---------|---------|---------|-------|--------|
| Age [Myr] | 1 | 1 | 1 | 2 | 5–10 |
| Distance [pc] | 300 | 125 | 200 | 160 | 145 |
| Surveyed Area [deg\(^2\)] | 0.15 | 0.33 | 1.4 | 0.25 | 37 |
| Completeness [\(M_\odot\)] at \(A_V\) (mag) | 0.000–0.005 | 0.001–0.010 | 0.006–0.012 | 0.005–0.030 | 0.001–0.030 |
| # of subst. candidates | 196 (opt) + 10 (Spitz) | 309 (opt) + 83 (Spitz) | 409 (opt-NIR) | 142 (opt) + 96 (opt-NIR) |
| # of spectra | 160 | 160 | 125 | 60 | 30 |
| # of Brown Dwarfs | 30–40 | ~15 | ~4 | ~9 | 15–20 |

Papers
- Scholz + 2009
- Scholz + 2012a
- Scholz + 2012b
- Scholz + subm.
- Geers + 2011
- Muzic + 2012
- Muzic + in prep.
- Muzic + 2011
- Dawson + 2011
- Dawson + 2013
- Dawson + in prep.

**Sub-stellar Mass Function**

Through SONYC and similar surveys by other groups, the sub-stellar IMF is now well characterized down to 5-10 \(M_{\text{Jup}}\).

Available star-to-BD ratios suggest environmental variations:

Yet, these ratios are not all derived consistently, and need a more detailed assessment of uncertainties. Addressing this in a forthcoming paper, we find that the range of ratios is likely smaller (2.5-5), though this variation may still imply that BD formation is dependent on environment.

**Brown Dwarfs**

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**Planetary Mass Objects**

Down to ~5 \(M_{\text{Jup}}\), free-floating planetary mass objects are observed to be rare, 20-50 times less numerous than stars.

These findings a.) imply that the total contribution of planetary mass objects to the mass budget of the clusters can be neglected, and b.) disagree strongly with recent microlensing survey claims of free-floating planetary mass objects being twice as common as stars.

**Access to the data | Questions / Comments?**

Spectra, photometric catalogues, and links to SONYC publications are available at: browndwarfs.org/sonyc

For questions/comments please contact: Vincent Geers, vgeers@cp.dias.ie