

# 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 object, 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](http://browndwarfs.org/sonyc)

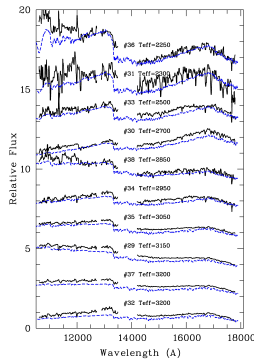
## SONYC Survey

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



Subaru SuprimeCam / MOIRCS iJK<sub>s</sub> image of NGC 1333.

Candidate verification through extensive follow-up spectroscopy.



MOIRCS spectra (black) of newly discovered low-mass stars and BDs in NGC 1333, with DUSTY model spectra (blue).

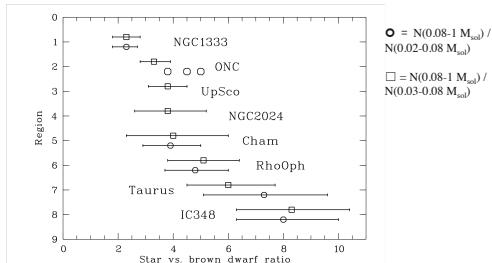
Summary of SONYC survey to date.

	NGC1333	Rho Oph	Lupus 3	Cha I	Up Sco
Age [Myr]	1	1	1	2	5-10
Distance [pc]	300	125	200	160	145
Surveyed Area [deg <sup>2</sup> ]	0.25	0.33	1.4	0.25	57
Completeness [M <sub>sol</sub> ] at A <sub>v</sub> (mag)	0.004-0.008 0-5	0.003-0.03 0-15	0.009-0.02 0-5	0.008 ≤ 5	0.02 ≤ 5
# 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

### Brown Dwarfs

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:

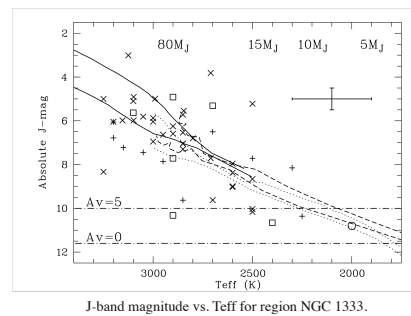


Comparison of star-to-brown-dwarf ratio for nearby young clusters reported in the literature (Scholz 2012b).

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.

### Planetary Mass Objects

Down to  $\sim 5 M_{\text{Jup}}$ , 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 micro-lensing 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](http://browndwarfs.org/sonyc)

For questions/comments please contact:  
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