Subaru Telescope
National Astronomical Observatory of Japan

Semester	S18B
Proposal ID	PROPIDTMP
Received	RECEIVETMP

Application Form for Telescope Time (Normal+Intensive Programs)

1. Title of Proposal

The mass distribution in quasars revealed by quasars as gravitational lenses

2. Principal Investigator

Name: Rusu CristianEduard

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3. Scientific Category

- ☐ Solar System
- ☐ Extrasolar Planets
- ☐ Star Formation and Young Disk
- ☐ ISM
- ☐ Normal Stars
- ☐ Metal-Poor Stars
- ☐ Compact Objects and SNe
- ☐ Milky Way
- ☐ Local Group
- ☐ Nearby Galaxies
- ☐ IGM and Abs.Line Systems
- ☐ Cosmology
- ☑ Gravitational Lenses
- ☐ Clusters and Proto-Clusters
- ☐ Galaxy Properties and Environment
- ☐ High-z Galaxies(LAEs, LBGs)
- ☐ High-z Galaxies(others)
- ☐ AGN and QSO Activity
- ☐ Miscellaneous

4. Abstract *(approximately 200 words)*

We propose IRCS+AO188+LGS Kp-band imaging observations of 11 newly discovered candidates of quasars acting as gravitational lenses. Given the high purity demonstrated in the past, we expect that our observations will almost quadruple the number of such systems known to date. By spending one hour per system, including overheads, for a total of 2x0.5 = 1 night, we will test the lensing nature of these candidates as well as measure the luminosity of the quasar host galaxies. Furthermore, we will model the extended background sources, constraining the mass and radial mass profile of the foreground quasar host galaxies, discriminating between different quasar halo models, and studying the evolution with redshift of the scaling laws between the supermassive black hole mass, the quasar host luminosity, and the quasar host central velocity dispersion.

5. Co-Investigators

Name	Institute	Name	Institute
Anupreeta More	IPMU		
Romain Meyer	Univ. College London		
Frederic Courbin	EPFL		

6. Thesis Work

☐ This proposal is linked to the thesis preparation of _____

7. Subaru Open Use Intensive Programs

☑ This is a proposal for Intensive Programs.

8. List of Applicants' Related Publications *(last 5 years)*

Meyer et al., arXiv:1711.01184 (2017)
Rusu, C. E. et al., MNRAS, 467, 4220 (2017)
Rusu, C. E. et al., MNRAS, 458, 2 (2016)
More A., et al., MNRAS, 456, 1595 (2016)
Rusu, C. E. et al., MNRAS, 444, 2561 (2014)
Oguri, M., Rusu C. E., Falco, E. E., MNRAS, 439, 3 (2014)
Rusu C. E. et al., AJ, 765, 139 (2013)

9. Condition of Closely-Related Past and Scheduled Observations

Please fill in here, if this proposal is a continuation of (or inextricably related with) the previously accepted proposals. This is to describe what kind of relevant/similar proposals have existed in the past. If your scheduled observation exists, please describe it.

Proposal ID	Title (may be abbreviated)	Observational condition	Achievement (%)

10. Post-Observation Status and Publications

Please report the status or outcome of your main Subaru observations carried out in the past. All observations relevant to this proposal should be included here. Similarly, all those within last 3 years with which you were involved as P.I. must be reported.

Year/Month	Proposal ID	PI name	Status: completion/reduction/analysis	Status: publication
Sept 2013	S13B-002	C. E. Rusu	completed	1 paper (MNRAS)
Feb 2013	S13A-075	C. E. Rusu	completed	1 paper (MNRAS)
Feb 2012	S12A-024	C. E. Rusu	completed	1 paper (MNRAS)
Feb 2012	S12A0134S	C. E. Rusu	completed	1 paper above

11. Experience

The PI has experience observing with IRCS+AO188 as principal investigator in the past, for the multi-semester proposal entitled "Subaru Telescope LGSAO imaging of Gravitationally Lensed Quasars". This has resulted in multiple publications as well as a PhD. We do not require assistance in addition to what is typically provided by the support astronomer during the observing nights.

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12. Observing Run

Instrument	#Nights	Moon	Preferred Dates	Acceptable Dates	Observing Modes
IRCS+LGS-AO	0.5	gray	Early Jan. -	Mid Dec. -	imaging
IRCS+LGS-AO	0.5	gray	Early Aug. - Late Nov.	Early Aug. - Mid Dec.	imaging

2nd choice: IRCS+NGS+AO is partly acceptable as replacement to IRCS+LGS+AO (5/11 targets).

comments: N/A

Total Requested Number of Nights [1] Minimum Acceptable Number of Nights [1]

13. Scheduling Requirements

☐ ToO ☐ Time Critical *Remote Observation* ☐ at Hilo ☐ at Mitaka

2x0.5 nights are required due to half the targets having optimal visibility early in the semester, and the other half late in the semester.

14. List of Targets

Target Name	RA	Dec	Magnitude (Band)
SDSS J0050+1501	005030.65	+150134.0	K=16.75
SDSS J0148+0324	014819.57	+032424.9	K=16.96
SDSS J0913+6045	091318.66	+604529.8	r=19.91
SDSS J0920-0222	092012.67	-022230.4	K=16.39
SDSS J1140+0007	114059.35	+000727.3	K=16.41
SDSS J1229+2156	122905.05	+215659.8	K=16.69
SDSS J1510+1856	151020.36	+185632.2	r=19.87
SDSS J2334+3021	233443.68	+302159.9	K=14.12
SDSS J0139+0106	013934.96	+010629.9	K=18.39
SDSS J1016+5034	101625.37	+503427.0	r=19.98
SDSS J2354+1951	235422.48	+195141.3	r=18.58

No comments.

15. Observing Method and Technical Details

Please describe in detail about instrument configuration, exposure time, required sensitivity, and so on.

All of our targets have either a suitable tip-tilt star or a natural guide star. Their magnitudes and separations from the targets are listed in the table below.

Name	mag	dist	Name	mag	dist
SDSS J0050+1501	$R = 15.5$	$41''$	SDSS J0148+0324	$R = 16.9$	$30''$
SDSS J0913+6045	$R = 14.8$	$21''$	SDSS J0920-0222	$R = 16.0$	14"
SDSS J1140+0007	$R = 15.3$	$55''$	SDSS J1229+2156	$R = 14.5$	$69''$
SDSS J1510+1856	$R = 15.1$	$39''$	SDSS J2334+3021	$R = 13.0$	$30''$
SDSS J0139+0106	$R = 16.0$	$21''$	SDSS J1016+5034	$R = 16.9$	$19.5''$
SDSS J2354+1951	$R = 14.1$	$22''$			

Table: Summary of our tip-tilt stars for the IRCS LGS-AO observation. "Mag" is the magnitude of the tip-tilt star and "dist" is the angular distance of the tip-tilt star from the target.

The median background galaxy redshift in our sample is ~ 0.75. Typical emission line galaxies with Hβ, OIII and OII lines expected to be picked up by the SDSS fibers at this redshift have $r \sim 17.6$, which corresponds to $K \sim 19.2$ (Vega). We will observe in K' band, where the AO correction is better, with the 52mas pixel scale. By observing each target for one hour (45 min (60s x 45) + 15 min overhead for slewing and optimizing the AO loop), according to the IRCS ETC, we will achieve S/N $\sim$ 4 per pixel for these background galaxies. The actual S/N which will be achieved is difficult to predict, as it is an interplay between the gravitational lensing effect magnifying and stretching the sources, and additional shot noise from the bright lensing quasar. In a standard aperture, these sources will be detected at high S/N $\sim$ 40, which will easily allow to test their lensing nature.

The lensing quasars have median $K \sim 16.7$, and will therefore be observed at very high S/N. Assuming that the host galaxies are $\sim$ 4 mag (integrated) fainter, they will be detected at S/N$\sim$ 20.

During the observations, in case we determine from the first few frames that some of the candidates are not real lenses, we will use the remaining time for those systems to observe individual stars, close on the sky and prepared ahead of time, of similar brightness to the target, and with tip-tilts of similar magnitude and separation. We will use these as PSFs to conduct simulations and understand to what precision we can disentangle the quasar components from their host galaxies.

Finally, we will be observing one standard star each night.

16. Instrument Requirements *Specify the number of masks (MOIRCS/MOS) or the set of filters to use (HSC).*

N/A

17. Backup Proposal in Poor Conditions *(specify object names)*

In case LGS mode becomes unavailable, we will observe part of our targets in NGS mode. If AO observations are unavailable, we will observe the more spatially extended targets only.

18. Public Data Archive of Subaru

☒ *Yes, I have checked SMOKA.*

If your targets have already been observed by Subaru in the past, please describe why you need to observe them again.

None of the targets have been observed with IRCS before.

19. Justify Duplications with the HSC SSP *(for HSC proposers)*

N/A