Resubmission of 07B-0289

NOAO Observing Proposal *Longterm proposal* **Panel:** *For office use.*
Date: September 26, 2007 **Category:** Cosmology

Normalization and scatter of the mass-temperature relation for supermassive galaxy clusters

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Abstract of Scientific Justification *(will be made publicly available for accepted proposals)*:
We propose a high-accuracy survey of the 20 most massive clusters in the northern hemisphere at $0.15 < z < 0.3$, to yield a uniform catalog of X-ray, galaxy, and dark-matter properties (from weak gravitational lensing, WL). All quantities will be determined with high S/N and low systematic errors. The major scientific goals are to (a) determine the normalization *and scatter* in the mass-temperature relation for massive clusters, which is essential for the use of clusters to constrain cosmological parameters, and (b) use the relations between WL mass, X-ray temperature, and other structural variables to validate numerical models of cluster evolution. There has to date been no cluster lensing survey with sufficiently large sample size and sufficiently low random and systematic errors to infer the intrinsic component of the M-T scatter. We expect to determine the scatter in the M-T relation to ±5%. All targets have existing Chandra, XMM, and ASCA X-ray data, HST strong-lensing imaging, and most have existing good-seeing images from Subaru. Our project will complete the WL imaging and, with this proposal, obtain multiband Mosaic observations for photometric redshifts. Uniform photo-z's are essential to properly calibrate the WL data and isolate the (unlensed) cluster member galaxies.

Summary of observing runs requested for this project

Run	Telescope	Instrument	No. Nights	Moon	Optimal months	Accept. months
1	KP-4m	MOSA	2	darkest	Feb - Apr	Feb - Jun
2	KP-4m	MOSA	2	dark	Feb - Apr	Feb - Jun
3	KP-4m	MOSA	2	grey	Feb - Apr	Feb - Jun
4						
5						
6						

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

18 of 21 target fields are in the 8-17h RA range, so Feb-Apr are the most productive months in 2008A (Feb-Jun acceptable). Since we are requesting long-term status, we have suggested splitting the observing time into 6 nights in 2008A and 5 in 2008B (Dec-Jan preferred, Nov-Jan acceptable), but it would be possible to adjust this split somewhat.

Scientific Justification *Be sure to include overall significance to astronomy. For standard proposals limit text to one page with figures, captions and references on no more than two additional pages.*

The abundance of galaxy clusters is a key measure of dark energy (Albrecht et al. 2006), and the properties of massive clusters provide very stringent tests of theories of gravitational collapse. We have designed a survey to obtain the most precise and accurate measures to date of galaxy-cluster projected masses, X-ray properties, and galaxy contents, to facilitate new tests of cluster models and to evaluate the suitability of galaxy clusters as a dark-energy test.

Survey summary: The targets are the 20 most massive galaxy clusters in the northern hemisphere with $0.15 < z < 0.3$, selected by X-ray temperature to have $M > 10^{15} h^{-1} M_{\odot}$. Focusing on the most massive clusters gives the most precise tests of models because it maximizes the S/N level of the observations, particularly the weak gravitational lensing (WL) mass determinations. The X-ray surveys and pointed followups are complete in this mass-redshift range, so we can select a complete sample and conduct meaningful statistical studies.

This proposal is to obtain multi-color imaging of all galaxies in the cluster fields from the Mayall 4-meter, for determination of photometric redshifts that reliably identify cluster members and determine the redshift distribution of the source galaxies in the weak-lensing study. Many cluster catalogs and WL measurements exist, but this survey will be unique in its precise and accurate calibration of the WL masses for a sizable, fair sample.

Scatter in the M-T relation: The primary quantitative goal of our proposed survey is to carry out the first precision measurement of the normalization *and scatter* between cluster X-ray observables and the true projected mass of galaxy clusters, determined via WL. Knowledge of this scatter is essential for the use of galaxy cluster abundances to constrain dark energy with upcoming cluster surveys (Albrecht et al. 2006, Lima & Hu 2005), such as Planck, ACT (Kosowsky 2006) and SPT. Fig. 1 (Mandelbaum & Seljak 2007) shows that without knowing the size of the lognormal mass-observable scatter when determining σ_8 from abundance measurements of clusters at $M > 5 \times 10^{14} h^{-1} M_{\odot}$, it is impossible to constrain σ_8 to within ~ 0.1. Past halo-abundance studies have had to assume a mean relation *and* scatter between halo mass and X-ray observable to extract cosmological information (*e.g.*, Ikebe et al. 2002).

Our survey will measure the mass scatter to $\pm 5\%$, assuming intrinsic scatter in $M(T_x)$ of 20% (Kravtsov et al. 2006). This project will be the first to produce WL masses with measurement error below the intrinsic scatter, for a sample large and complete enough to determine the scatter.

Cluster model validation: The mean and scatter in $M(T_x)$ are of intrinsic interest aside from their utility for cosmology. N-body+hydrodynamics models of galaxy clusters are quite advanced and make definitive, testable predictions for $M(T_x)$. Right now, there are still $\sim$ 20% normalization discrepancies between scaling relations in simulations and observations (Arnaud et al. 2007, Nagai et al. 2007). Since WL is the only path to accurate mass estimates for the unrelaxed clusters, there is substantial motivation for highest-quality data on a fairly-selected sample of clusters.

Our survey will also enable many new tests of models by determining distributions of other observables (e.g., concentration parameters and multipole moments of the X-ray and dark matter distributions), measurable at useful S/N in supermassive clusters (without stacking).

An important subtlety is that most models refer to cluster 3d virial masses whereas WL measures a 2d mass, which includes the cluster virial core, nonvirialized structure local to the cluster (Metzler et al. 2000), and large-scale structure projected along the line of sight (Hoekstra 2003). We have a new $1/h$ Gpc N-body simulation that can determine the two projection effects with much greater statistical power than before, so we can remove their contribution and estimate the intrinsic scatter in virial $M(T_x)$ to high precision.

References

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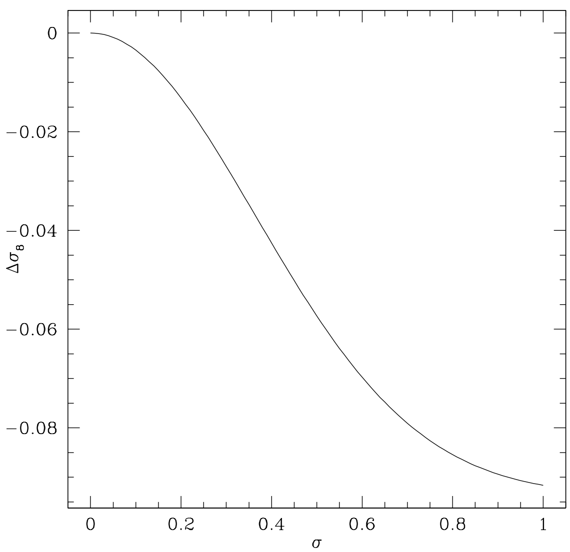

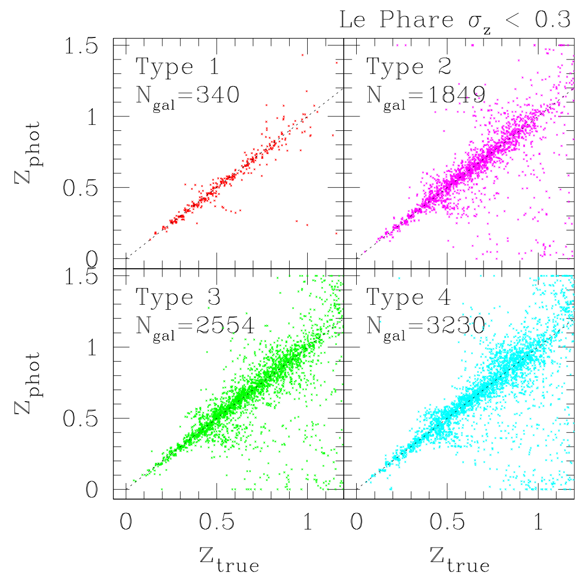

Figure 1: Left: Bias in σ_8 (at fixed Ω_m) in a cluster-counting survey using an observational threshold around $5 \times 10^{14} h^{-1} M_\odot$ with an observable with lognormal scatter of size σ. Right: Comparison of true redshift to photo-z, estimated using LePhare photo-z code (Ilbert et al., 2006) with our chosen filters and limiting magnitudes. Type 1 represents the red elliptical galaxies, while Type 4 represents the blue star-forming galaxies, and Types 2 and 3 are intermediate types. The simulated source sample is dominated by faint blue galaxies with $0.8 < z < 1.2$.

Experimental Design *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 survey is carefully designed to allow us to meet our goal of measuring the full $M(T_x)$ relation, including scatter. Recently published WL cluster studies (*e.g.*, Bardeau et al. 2007, Mahdavi et al. 2007) demonstrate that our overall methodology is reasonable, but that a new survey is required: Bardeau et al. 2007 state explicitly that their sample is too small, with uncertainties in individual masses that are too large to determine intrinsic scatter.

In constrast, we use the most massive clusters to maximize S/N. We also require very low *systematic* errors in WL measurement. Co-I's on this proposal have developed *three* of the best-performing WL pipelines ($\sim 2\%$ accuracy) in the STEP2 tests (Massey et al. 2007), which were modeled on the deep, wide-field Subaru data that we will use for our WL analysis. Many WL cluster mass estimates have large calibration uncertainties ($\sim 20\%$) due to ignorance of the source dN/dz; the multi-band photo-z data will reduce the calibration uncertainty by a factor of 10. The photo-z data will also reliably identify cluster galaxies, which would otherwise contaminate the source sample and suppress the lensing signal in the inner cluster regions at the $\sim 30\%$ level (Limousin et al. 2006). In short, without these homogeneous photo-z data, our goal of precisely determining the $M(T_x)$ relation will be impossible due to systematic errors that are a factor of 10 too high.

Sample selection and size: Our Fisher matrix analysis suggests that with $M_{180\overline{\rho}} \sim 10^{15}h^{-1}M_{sun}$ we can achieve a statistical error on the projected cluster mass of 5% per cluster. This measurement error is far below the other sources of scatter discussed in the scientific justification, so the ensemble mean value of M can be determined to 9%, and the total scatter in the 2d mass at fixed X-ray temperature can be determined to within 5% with 20 clusters. When combined with the N-body simulations to determine the scatter due to large-scale structure along the line of sight and the projection from 2d to 3d, we can subtract off those contributions to determine the scatter in the $M(T_x)$ relation to high precision (i.e. 5% out of an expected 20%, or one part in four).

The X-ray temperature is more highly correlated with the cluster mass than the X-ray luminosity; we require $T_x > 6.5$ keV to obtain virial masses $> 10^{15}h^{-1}M_\odot$ (Dahle et al. 2002, Smith et al. 2005). We choose the redshift range $0.15 < z < 0.3$, which gives the optimal combination of high lensing efficiency and X-ray flux. Our selection criteria lead to an unbiased sample of supermassive clusters, because we do not eliminate complex or merging systems.

Photo-z calibration: Besides the 20 clusters (19 targets, one of which is a double cluster that will fit in a single pointing), we must also observe 2 photo-z calibration fields, the DEEP2 Extended Groth Strip (EGS) and 02h30m+00 00 (02h) in $Cg'r'i'z'$. In the DEEP2 02h field, a single pointing can image up to ~ 2700 galaxies with high-quality spectroscopic redshifts (spectro-z with $0.7 < z < 1.2$). At lower redshift, we will use 1200 DEEP2 EGS redshifts, which are approximately flux-limited to $R < 24$, and by using ~ 1000 Prism Multi-object Survey (PRIMUS) redshifts at $R < 23.3$ to complement the color cut in the DEEP2 02h field.

Required exposure depths: We have used the Le Phare photo-z code (Ilbert et al. 2006) to simulate a realistic photo-z sample given our exposure times and limiting magnitudes in each band with the COMBO-17 spectral type-dependent R-band luminosity function (Wolf et al. 2003). We have found that our limiting magnitudes provide photo-z accuracy that reduces contamination from cluster member galaxies to the 2–3% level at the minimum scale used for lensing; reduces redshift-related calibration error to $< 1\%$; and provides photo-z's for 60–70% of sources, giving a usable source number density of ~ 20 arcmin^{-2} (see Fig 1).

Proprietary Period: None

Use of Other Facilities or Resources *(1) Describe how the proposed observations complement data from non-NOAO facilities. For each of these other facilities, indicate the nature of the observations (yours or those of others), and describe the importance of the observations proposed here in the context of the entire program. (2) Do you currently have a grant that would provide resources to support the data processing, analysis, and publication of the observations proposed here?"*

The NOAO photo-z data proposed herein will be supplemented by single-band wide-field imaging with seeing $0\farcs9$ or better for WL purposes. Suitable data is or will soon be (by 2/08) publicly available in the Subaru archive for 11 of the 20 clusters. Pending proposals to Subaru and the MMT would provide the ≈ 2 nights to complete the WL imaging.

All of the target clusters have pre-existing Chandra and/or XMM X-ray data with well-determined ASCA temperatures, and HST WFPC2 and/or ACS imaging of the cluster cores to reveal any strongly lensed features. The X-ray data are sufficient not just to obtain average temperatures, but also mass profiles. Twelve clusters also have publicly-available Spitzer IRAC data in the cluster center that will supplement the KPNO data to get photo-z's for $z > 1$ sources.

Existing computational resources at the investigators' institutions will suffice to store and reduce these data. The code for the weak lensing data reduction and analysis, for the production of X-ray temperature maps, and for photometric redshift computation already exists.

Long-term Details *If you are requesting long term status, list the observing runs (telescope, instrument, number of nights) requested in subsequent semesters to complete the project.*

Due to the range of right ascension of our targets, they cannot all be observed in one semester, so we are requesting long-term status to observe in S2008B as well. We are requesting 6 nights for observation in S2008A and 5 in S2008B, but it would be possible to adjust this split somewhat. The observing runs in S2008B will be the same as for S2008A, except that the first observing run will only take 1 day instead of two.

Please note that a survey proposal for these observations is also being considered by the survey TAC.

Previous Use of NOAO Facilities *List allocations of telescope time on facilities available through NOAO to the PI during the last 2 years for regular proposals, and at any time in the past for survey proposals (including participation of the PI as a Co-I on previous NOAO surveys), 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. Please include original proposal semesters and ID numbers when available.*

The PI has not previously used any NOAO facilities.

Observing Run Details for Run 1: KP-4m/MOSA

Technical Description *Describe the observations to be made during this observing run. Justify the specific telescope, the number of nights, the instrument, and the lunar phase. List objects, coordinates, and magnitudes (or surface brightness, if appropriate) in the Target Tables section below (required for queue and Gemini runs).*

We request darkest-time (lunar phase < 3) observation in Washington C and SDSS g' bands with the KPNO-4m telescope (Mosaic imager). For each target, we require 60 minutes of integration time split into 6 exposures in C band, and 30 minutes of integration time split into 3 exposures in g' band, to reach limiting magnitudes of 24.8 and 25.3 (point source $S/N = 10$) respectively. For these bands, we restrict observations to airmass< 1.3. We can thus observe up to 18/21 targets in 2008A (Feb-Apr) and up to 12/21 in 2008B (Dec-Jan). Including integration+readout time, with 30 minutes for observing photometric standards each night, we require 4 nights total for this observation across 2 semesters. While we request 2 nights in 2008A and 2 in 2008B it would be possible to adjust these numbers somewhat.

Instrument Configuration

Filters: C, g'	Slit:	Fiber cable:
Grating/grism:	Multislit:	Corrector:
Order:	λ_{start}:	Collimator:
Cross disperser:	λ_{end}:	Atmos. disp. corr.:

R.A. range of principal targets (hours): 0 to 18

Dec. range of principal targets (degrees): -2 to 67

Special Instrument Requirements *Describe briefly any special or non-standard usage of instrumentation.*

Target Table for Run 1: KP-4m/MOSA

Obj ID	Object	α	δ	Epoch	Mag.	Filter	Exp. time	# of exp.	Lunar days	Sky	Seeing	Comment
	ABELL0068	00:36:59.40	09:08:30.1	J2000		C	600	6	1	phot	1.1	
	ABELL0267	01:52:52.25	01:02:45.6	J2000		C	600	6	1	phot	1.1	public Subaru
	PHOTOZ02	02:30: 0.00	00:00: 0.0	J2000		C	600	6	1	phot	1.1	calibration field
	ABELL0611	08:00:58.08	36:04:41.5	J2000		C	600	6	1	phot	1.1	public Subaru
	ABELL0665	08:30:45.20	65:52:55.3	J2000		C	600	6	1	phot	1.1	
	ABELL0697	08:42:53.33	36:20:11.6	J2000		C	600	6	1	phot	1.1	public Subaru
	ABELL0773	09:17:59.39	51:42:23.1	J2000		C	600	6	1	phot	1.1	
	ABELL0963	10:17: 9.65	39:01: 0.1	J2000		C	600	6	1	phot	1.1	public Subaru
	ZwCl3146	10:23:39.63	04:11:10.4	J2000		C	600	6	1	phot	1.1	
	ABELL1576	12:36:49.12	63:11:30.2	J2000		C	600	6	1	phot	1.1	
	ABELL1682	13:06:49.72	46:32:58.9	J2000		C	600	6	1	phot	1.1	
	ABELL1689	13:11:34.20	-01:21:55.5	J2000		C	600	6	1	phot	1.1	public Subaru
	ABELL1758	13:32:32.10	50:30:36.9	J2000		C	600	6	1	phot	1.1	public Subaru
	ABELL1763	13:35:17.20	40:59:58.0	J2000		C	600	6	1	phot	1.1	
	ABELL1835	14:01: 2.03	02:51:31.5	J2000		C	600	6	1	phot	1.1	public Subaru
	PHOTOZ14	14:19:12.40	52:43:42.	J2000		C	600	6	1	phot	1.1	calibration field
	ABELL1914	14:26: 2.97	37:49:32.0	J2000		C	600	6	1	phot	1.1	public Subaru
	ABELL2111	15:39:38.34	34:24:20.5	J2000		C	600	6	1	phot	1.1	
	ABELL2218	16:35:53.99	66:13: 0.2	J2000		C	600	6	1	phot	1.1	
	ABELL2219	16:40:21.12	46:41:15.8	J2000		C	600	6	1	phot	1.1	public Subaru
	ABELL2261	17:22:28.34	32:09:12.7	J2000		C	600	6	1	phot	1.1	public Subaru
	ABELL0068	00:36:59.40	09:08:30.1	J2000		g'	600	3	1	phot	1.1	
	ABELL0267	01:52:52.25	01:02:45.6	J2000		g'	600	3	1	phot	1.1	public Subaru
	PHOTOZ02	02:30: 0.00	00:00: 0.0	J2000		g'	600	3	1	phot	1.1	calibration field
	ABELL0611	08:00:58.08	36:04:41.5	J2000		g'	600	3	1	phot	1.1	public Subaru
	ABELL0665	08:30:45.20	65:52:55.3	J2000		g'	600	3	1	phot	1.1	
	ABELL0697	08:42:53.33	36:20:11.6	J2000		g'	600	3	1	phot	1.1	public Subaru
	ABELL0773	09:17:59.39	51:42:23.1	J2000		g'	600	3	1	phot	1.1	
	ABELL0963	10:17: 9.65	39:01: 0.1	J2000		g'	600	3	1	phot	1.1	public Subaru
	ZwCl3146	10:23:39.63	04:11:10.4	J2000		g'	600	3	1	phot	1.1	
	ABELL1576	12:36:49.12	63:11:30.2	J2000		g'	600	3	1	phot	1.1	
	ABELL1682	13:06:49.72	46:32:58.9	J2000		g'	600	3	1	phot	1.1	
	ABELL1689	13:11:34.20	-01:21:55.5	J2000		g'	600	3	1	phot	1.1	public Subaru
	ABELL1758	13:32:32.10	50:30:36.9	J2000		g'	600	3	1	phot	1.1	public Subaru
	ABELL1763	13:35:17.20	40:59:58.0	J2000		g'	600	3	1	phot	1.1	
	ABELL1835	14:01: 2.03	02:51:31.5	J2000		g'	600	3	1	phot	1.1	public Subaru
	PHOTOZ14	14:19:12.40	52:43:42.	J2000		g'	600	3	1	phot	1.1	calibration field
	ABELL1914	14:26: 2.97	37:49:32.0	J2000		g'	600	3	1	phot	1.1	public Subaru
	ABELL2111	15:39:38.34	34:24:20.5	J2000		g'	600	3	1	phot	1.1	
	ABELL2218	16:35:53.99	66:13: 0.2	J2000		g'	600	3	1	phot	1.1	
	ABELL2219	16:40:21.12	46:41:15.8	J2000		g'	600	3	1	phot	1.1	public Subaru
	ABELL2261	17:22:28.34	32:09:12.7	J2000		g'	600	3	1	phot	1.1	public Subaru

Observing Run Details for Run 2: KP-4m/MOSA

Technical Description *Describe the observations to be made during this observing run. Justify the specific telescope, the number of nights, the instrument, and the lunar phase. List objects, coordinates, and magnitudes (or surface brightness, if appropriate) in the Target Tables section below (required for queue and Gemini runs).*

We request dark-time (lunar phase < 7) observation in the SDSS r' and i' bands with the KPNO-4m telescope (Mosaic imager). For each target, we require 30 minutes of integration time split into 3 exposures in r' band; and 60 minutes of integration time split into 6 exposures in i' band. We can then expect to reach a limiting magnitude of 24.8 in r' and 24.7 in i' (point source $S/N = 10$). For these bands, we restrict observations to airmass< 1.6. Including integration+readout time, with 30 minutes for observing photometric standards each night, we request 2 nights of observation in S08A and 2 nights in S08B. There is some freedom to adjust the allocation between the two semesters, as discussed in the description for observing run 1.

Instrument Configuration

Filters: r', i'	Slit:	Fiber cable:
Grating/grism:	Multislit:	Corrector:
Order:	λ_{start}:	Collimator:
Cross disperser:	λ_{end}:	Atmos. disp. corr.:

R.A. range of principal targets (hours): 0 to 18

Dec. range of principal targets (degrees): -2 to 67

Special Instrument Requirements *Describe briefly any special or non-standard usage of instrumentation.*

Target Table for Run 2: KP-4m/MOSA

Obj ID	Object	α	δ	Epoch	Mag.	Filter	Exp. time	# of exp.	Lunar days	Sky	Seeing	Comment
	ABELL0068	00:36:59.40	09:08:30.1	J2000		r'	600	3	5	phot	1.1	
	ABELL0267	01:52:52.25	01:02:45.6	J2000		r'	600	3	5	phot	1.1	public Subaru
	PHOTOZ02	02:30: 0.00	00:00: 0.0	J2000		r'	600	3	5	phot	1.1	calibration field
	ABELL0611	08:00:58.08	36:04:41.5	J2000		r'	600	3	5	phot	1.1	public Subaru
	ABELL0665	08:30:45.20	65:52:55.3	J2000		r'	600	3	5	phot	1.1	
	ABELL0697	08:42:53.33	36:20:11.6	J2000		r'	600	3	5	phot	1.1	public Subaru
	ABELL0773	09:17:59.39	51:42:23.1	J2000		r'	600	3	5	phot	1.1	
	ABELL0963	10:17: 9.65	39:01: 0.1	J2000		r'	600	3	5	phot	1.1	public Subaru
	ZwCl3146	10:23:39.63	04:11:10.4	J2000		r'	600	3	5	phot	1.1	
	ABELL1576	12:36:49.12	63:11:30.2	J2000		r'	600	3	5	phot	1.1	
	ABELL1682	13:06:49.72	46:32:58.9	J2000		r'	600	3	5	phot	1.1	
	ABELL1689	13:11:34.20	-01:21:55.5	J2000		r'	600	3	5	phot	1.1	public Subaru
	ABELL1758	13:32:32.10	50:30:36.9	J2000		r'	600	3	5	phot	1.1	public Subaru
	ABELL1763	13:35:17.20	40:59:58.0	J2000		r'	600	3	5	phot	1.1	
	ABELL1835	14:01: 2.03	02:51:31.5	J2000		r'	600	3	5	phot	1.1	public Subaru
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	ABELL1914	14:26: 2.97	37:49:32.0	J2000		r'	600	3	5	phot	1.1	public Subaru
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	ABELL2218	16:35:53.99	66:13: 0.2	J2000		r'	600	3	5	phot	1.1	
	ABELL2219	16:40:21.12	46:41:15.8	J2000		r'	600	3	5	phot	1.1	public Subaru
	ABELL2261	17:22:28.34	32:09:12.7	J2000		r'	600	3	5	phot	1.1	public Subaru
	ABELL0068	00:36:59.40	09:08:30.1	J2000		i'	600	6	5	phot	1.1	
	ABELL0267	01:52:52.25	01:02:45.6	J2000		i'	600	6	5	phot	1.1	public Subaru
	PHOTOZ02	02:30: 0.00	00:00: 0.0	J2000		i'	600	6	5	phot	1.1	calibration field
	ABELL0611	08:00:58.08	36:04:41.5	J2000		i'	600	6	5	phot	1.1	public Subaru
	ABELL0665	08:30:45.20	65:52:55.3	J2000		i'	600	6	5	phot	1.1	
	ABELL0697	08:42:53.33	36:20:11.6	J2000		i'	600	6	5	phot	1.1	public Subaru
	ABELL0773	09:17:59.39	51:42:23.1	J2000		i'	600	6	5	phot	1.1	
	ABELL0963	10:17: 9.65	39:01: 0.1	J2000		i'	600	6	5	phot	1.1	public Subaru
	ZwCl3146	10:23:39.63	04:11:10.4	J2000		i'	600	6	5	phot	1.1	
	ABELL1576	12:36:49.12	63:11:30.2	J2000		i'	600	6	5	phot	1.1	
	ABELL1682	13:06:49.72	46:32:58.9	J2000		i'	600	6	5	phot	1.1	
	ABELL1689	13:11:34.20	-01:21:55.5	J2000		i'	600	6	5	phot	1.1	public Subaru
	ABELL1758	13:32:32.10	50:30:36.9	J2000		i'	600	6	5	phot	1.1	public Subaru
	ABELL1763	13:35:17.20	40:59:58.0	J2000		i'	600	6	5	phot	1.1	
	ABELL1835	14:01: 2.03	02:51:31.5	J2000		i'	600	6	5	phot	1.1	public Subaru
	PHOTOZ14	14:19:12.40	52:43:42.	J2000		i'	600	6	5	phot	1.1	calibration field
	ABELL1914	14:26: 2.97	37:49:32.0	J2000		i'	600	6	5	phot	1.1	public Subaru
	ABELL2111	15:39:38.34	34:24:20.5	J2000		i'	600	6	5	phot	1.1	
	ABELL2218	16:35:53.99	66:13: 0.2	J2000		i'	600	6	5	phot	1.1	
	ABELL2219	16:40:21.12	46:41:15.8	J2000		i'	600	6	5	phot	1.1	public Subaru
	ABELL2261	17:22:28.34	32:09:12.7	J2000		i'	600	6	5	phot	1.1	public Subaru

Observing Run Details for Run 3: KP-4m/MOSA

Technical Description *Describe the observations to be made during this observing run. Justify the specific telescope, the number of nights, the instrument, and the lunar phase. List objects, coordinates, and magnitudes (or surface brightness, if appropriate) in the Target Tables section below (required for queue and Gemini runs).*

We request grey-time observation in the SDSS z' band with the KPNO-4m telescope (Mosaic imager). For each target, we require 60 minutes of integration time split into 6 exposures to reach a limiting magnitude of 23.1 (point source $S/N = 10$). For this band, we restrict observations to airmass< 1.8. Including observation+readout time, with 30 minutes for observing photometric standards each night, we require 2 nights of observation in S08A and 1 night in S08B. There is some freedom to adjust the allocation between the two semesters, as discussed in the description for observing run 1.

Instrument Configuration

Filters: z'	Slit:	Fiber cable:
Grating/grism:	Multislit:	Corrector:
Order:	λ_{start}:	Collimator:
Cross disperser:	λ_{end}:	Atmos. disp. corr.:

R.A. range of principal targets (hours): 0 to 18

Dec. range of principal targets (degrees): -2 to 67

Special Instrument Requirements *Describe briefly any special or non-standard usage of instrumentation.*

Target Table for Run 3: KP-4m/MOSA

Obj ID	Object	α	δ	Epoch	Mag.	Filter	Exp. time	# of exp.	Lunar days	Sky	Seeing	Comment
	ABELL0068	**00:36:59.40**	**09:08:30.1**	**J2000**		**z'**	**600**	**6**	**9**	**phot**	**1.1**	
	ABELL0267	**01:52:52.25**	**01:02:45.6**	**J2000**		**z'**	**600**	**6**	**9**	**phot**	**1.1**	**public Subaru**
	PHOTOZ02	**02:30: 0.00**	**00:00: 0.0**	**J2000**		**z'**	**600**	**6**	**9**	**phot**	**1.1**	**calibration field**
	ABELL0611	**08:00:58.08**	**36:04:41.5**	**J2000**		**z'**	**600**	**6**	**9**	**phot**	**1.1**	**public Subaru**
	ABELL0665	**08:30:45.20**	**65:52:55.3**	**J2000**		**z'**	**600**	**6**	**9**	**phot**	**1.1**	
	ABELL0697	**08:42:53.33**	**36:20:11.6**	**J2000**		**z'**	**600**	**6**	**9**	**phot**	**1.1**	**public Subaru**
	ABELL0773	**09:17:59.39**	**51:42:23.1**	**J2000**		**z'**	**600**	**6**	**9**	**phot**	**1.1**	
	ABELL0963	**10:17: 9.65**	**39:01: 0.1**	**J2000**		**z'**	**600**	**6**	**9**	**phot**	**1.1**	**public Subaru**
	ZwCl3146	**10:23:39.63**	**04:11:10.4**	**J2000**		**z'**	**600**	**6**	**9**	**phot**	**1.1**	
	ABELL1576	**12:36:49.12**	**63:11:30.2**	**J2000**		**z'**	**600**	**6**	**9**	**phot**	**1.1**	
	ABELL1682	**13:06:49.72**	**46:32:58.9**	**J2000**		**z'**	**600**	**6**	**9**	**phot**	**1.1**	
	ABELL1689	**13:11:34.20**	**-01:21:55.5**	**J2000**		**z'**	**600**	**6**	**9**	**phot**	**1.1**	**public Subaru**
	ABELL1758	**13:32:32.10**	**50:30:36.9**	**J2000**		**z'**	**600**	**6**	**9**	**phot**	**1.1**	**public Subaru**
	ABELL1763	**13:35:17.20**	**40:59:58.0**	**J2000**		**z'**	**600**	**6**	**9**	**phot**	**1.1**	
	ABELL1835	**14:01: 2.03**	**02:51:31.5**	**J2000**		**z'**	**600**	**6**	**9**	**phot**	**1.1**	**public Subaru**
	PHOTOZ14	**14:19:12.40**	**52:43:42.**	**J2000**		**z'**	**600**	**6**	**9**	**phot**	**1.1**	**calibration field**
	ABELL1914	**14:26: 2.97**	**37:49:32.0**	**J2000**		**z'**	**600**	**6**	**9**	**phot**	**1.1**	**public Subaru**
	ABELL2111	**15:39:38.34**	**34:24:20.5**	**J2000**		**z'**	**600**	**6**	**9**	**phot**	**1.1**	
	ABELL2218	**16:35:53.99**	**66:13: 0.2**	**J2000**		**z'**	**600**	**6**	**9**	**phot**	**1.1**	
	ABELL2219	**16:40:21.12**	**46:41:15.8**	**J2000**		**z'**	**600**	**6**	**9**	**phot**	**1.1**	**public Subaru**
	ABELL2261	**17:22:28.34**	**32:09:12.7**	**J2000**		**z'**	**600**	**6**	**9**	**phot**	**1.1**	**public Subaru**