Japan Academy Prize to:

Satoshi Miyazaki
Director and Professor,
Subaru Telescope, National
Astronomical Observatory of Japan

and

Masamune Oguri
Professor,
Center for Frontier Science,
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for "Pioneering and Promoting Cosmological Research Using Gravitational Lensing Effects" (Joint Research)

Outline of the work:

The existence of unknown dark matter and dark energy was discovered through various astronomical observations over the last half-century. However, understanding the nature of dark matter and dark energy remains a major challenge in modern physics and cosmology. Although invisible, dark matter is detectable through its gravitational effects. The total mass of dark matter associated with galaxies and galaxy clusters is approximately five times that of stars and gases, and the dark matter is thought to have played a key role in forming the large-scale structure of the universe. No candidate such as nonluminous low-mass objects, primordial black holes, axions, or fuzzy dark matter has been yet identified as dark matter despite various observational and experimental searches.

The gravitational lensing effect of a massive cloud of dark matter influences light from sources behind, resulting in multiple images as well as image brightness enhancement and distortion. Multiple images of a quasar owing to a strong lensing effect were first detected in 1979, sparking interest in observing weak lensing effects to evaluate the distribution of dark matter.

In the 1990s, Dr. Satoshi Miyazaki led the development of Suprime-Cam, a wide-field CCD camera at the prime focus of the Subaru Telescope. He analyzed the first light images obtained in 2000 to evaluate subtle distortions in the images of distant galaxies behind a galaxy cluster. In 2002, he demonstrated the feasibility of retrieving the distribution of dark matter by solving the "inverse problem" of weak lensing effects. The retrieved distribution corresponds well with the distribution of galaxy clusters identified through X-ray and optical observations.

Building upon this success, Dr. Miyazaki proposed the construction of a larger camera for the Subaru Telescope: Hyper Suprime-Cam (HSC), featuring 106 CCD devices. He completed the construction in 2012 and led an international team in utilizing it to map the deep universe. This endeavor spanned 330 nights over seven years, commencing in 2014. With its wide field of view as well as excellent image quality and sensitivity, HSC is currently the world's largest camera that is employed in surveying the universe. HSC image data are openly available to the public and are utilized in various areas of astronomical research, including dark matter studies.

Dr. Masamune Oguri analyzed gravitationally lensed quasar images from the Sloan Digital Sky Survey to ascertain the distribution of dark matter in lensing galaxies. Additionally, he examined images captured by the Subaru Telescope and Hubble Space Telescope that include the effects of gravitational lensing for diverse investigations. He refined Dr. Miyazaki's weak-lensing study, yielding the three-dimensional spatial distribution of dark matter and its evolution over billions of years. Furthermore, he succeeded in unveiling the phenomenon of dark matter coalescence and aggregation. Moreover, Dr. Oguri and his collaborators indicated that the model of the expanding universe derived from the distribution of numerous galaxies at a redshift of approximately 1 may be inconsistent with the model obtained through analysis of the cosmic background radiation at a redshift of 1000.

Dr. Oguri further predicted that a newly found distant supernova would appear as multiple, time-delayed images owing to gravitational lensing effects; this was confirmed one year later. He made another notable discovery when he observed a lone, distant primordial star whose brightness was substantially intensified by an ultrastrong gravitational lensing effect while traversing the causal line of the lensing effect. This demonstrated that by carefully probing gravitational lensing effects we have chances to witness distant, faint objects that would never be visible.

Many of the abovementioned scientific achievements are recorded in the outstanding images obtained using HSC, which were developed and well-utilized by Dr. Miyazaki. The quality and quantity of HSC data are globally unparalleled. The observations using HSC are also expected to be jointly coordinated with those by the Euclid Space Telescope Project in Europe and the Rubin Telescope Project in the United States to evaluate the accelerating expansion of the universe. By conducting creative and precise analyses of valuable observational data from the perspective of gravitational lensing, Dr. Oguri demonstrated the possibility of directly observing the stars in the early universe—a feat beyond the sensitivity of existing large telescopes—by skillfully exploiting the amplification function of gravitational lensing.

Dr. Satoshi Miyazaki and Dr. Masamune Oguri, who led a series of pioneering investigations in gravitational lensing astronomy, are worthy of the Japan Academy Prize.

List of Main Publications (Dr. Satoshi Miyazaki)

1) "Subaru Prime Focus Camera —Suprime-Cam", **Miyazaki, S.**, Komiyama, Y., Sekiguchi, M., *et al.*, 2002, PASJ, 54, 833–853.
2) "Searching for Dark Matter Halos in the Suprime-Cam 2 Square Degree Field", **Miyazaki, S.**, Hamana, T., Shimasaku, K., *et al.*, 2002, ApJ Lett., 580, 97–100.
3) "A Subaru Weak-Lensing Survey. I. Cluster Candidates and Spectroscopic Verification",

Miyazaki, S., Hamana, T., Richard S. E., *et al*., 2007, ApJ, 669, 714–728.
4) "Properties of Weak Lensing Clusters Detected on Hyper Suprime-Cam's 2.3 square degree field", **Miyazaki, S.**, Oguri, M., Hamana, T., *et al*., 2015, ApJ, 807, 22–33.
5) "Hyper Suprime-Cam: System Design and Verification of Image Quality", **Miyazaki, S.**, Komiyama, Y., Kawanomoto, S., *et al*., 2018, PASJ, 70, S1 (1–26).
6) "The Hyper Suprime-Cam SSP Survey: Overview and Survey Design", Aihara, H., Arimoto, N., Armstrong, R., ..., **Miyazaki, S.**, ..., Oguri, M., *et al*., 2018, PASJ, 70, S4 (1-15).
7) "Two- and Three-dimensional Wide-field Weak Lensing Mass Maps from the Hyper Suprime-Cam Subaru Strategic Program S16A Data", Oguri, M., **Miyazaki, S.**, Hikage, C. *et al*., 2018, PASJ, 70, S26 (1–14).
8) "A Large Sample of Shear-selected Clusters from the Hyper Suprime-Cam Subaru Strategic Program S16A Wide Field Mass Maps", **Miyazaki, S.**, Oguri, M., Hamana, T., *et al*., 2018, PASJ, 70, S27 (1–23).
9) "Cosmology from Cosmic Shear Power Spectra with Subaru Hyper Suprime-Cam First-Year Data", Hikage,C., Oguri, M., Hamana, T., ..., **Miyazaki, S.**, *et al*., 2019, PASJ, 71, 43.
10) "Hundreds of Weak Lensing Shear-selected Clusters from the Hyper Suprime-Cam Subaru Strategic Program S19A Data", Oguri, M., **Miyazaki, S.**, Li, X., *et al*., 2021, PASJ, 73, 817–829.

List of Main Publications (Dr. Masamune Oguri)

1) "Gravitational Lens Time Delays: A Statistical Assessment of Lens Model Dependences and Implications for the Global Hubble Constant", **Oguri, M.**, 2007, ApJ, 660, 1.
2) "Gravitationally Lensed Quasars and Supernovae in Future Wide-Field Optical Imaging Surveys", **Oguri, M.** and Marshall P. J., 2010, MNRAS, 405, 2579–2593.
3) "Direct Measurement of Dark Matter Halo Ellipticity from Two-Dimensional Lensing Shear Maps of 25 Massive Clusters", **Oguri, M.**, Takada, M., Okabe, N., *et al*., 2010, MNRAS, 405, 2215–2230.
4) "Combined Strong and Weak Lensing Analysis of 28 Clusters from the Sloan Giant Arcs Survey", **Oguri, M.**, Matthews, B. B., Hakon, D., *et al*., 2012, MNRAS, 420, 3213–3239.
5) "Detection of the Gravitational Lens Magnifying a Type Ia Supernova", Quimby, R. M., **Oguri, M.**, More, A., *et al*., 2014, Science, 344, 396–399.
6) "Measuring the Distance-Redshift Relation with the Cross-Correlation of Gravitational Wave Standard Sirens and Galaxies", **Oguri, M.**, 2016, Phys. Rev. D, 93, 083511.
7) "Effect of Gravitational Lensing on the Distribution of Gravitational Waves from Distant Binary Black Hole Mergers", **Oguri, M.**, 2018, MNRAS, 480, 3842–3855.
8) "Understanding Caustic Crossings in Giant Arcs: Characteristic Scales, Event Rates, and Constraints on Compact Dark Matter", **Oguri, M.**, Diego, J. M., Kaiser, N., *et al*., 2018, Phys. Rev. D, 97, 023518.
9) "Cosmology from Cosmic Shear Power Spectra with Subaru Hyper Suprime-Cam First-Year Data", Hikage, C., **Oguri, M.**, Hamana T., *et al*., 2019, PASJ, 71, 43.
10) "A Comprehensive Study of Galaxies at z∼9-16 Found in the Early JWST Data: Ultravio-

let Luminosity Functions and Cosmic Star Formation History at the Preionization Epoch", Harikane, Y., Ouchi, M., **Oguri, M.** *et al*., 2023, ApJS, 265, 5.