【Grant-in-Aid for Specially Promoted Research】

Towards Ultimate Subaru: Galaxy formation history probed by deep near-infrared imaging with wide-field adaptive optics

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Purpose and Background of the Research

●Outline of the Research

Subaru Telescope has been leading wide-field studies of galaxy evolution utilizing its unique wide-field cameras. We now extend the wavelength to near-infrared (NIR) so that we can reach more distant galaxies in the early Universe to study galaxy formation. Wide-field observations have two advantages: one is to find rare objects on the sky such as massive galaxies in the early Universe and new type of supernova, and the other is to trace spatially extended objects such as large-scale structures in the early Universe. These observations can provide info on the processes of galaxy formation and the physical states of the early Universe.

For this purpose, we need to first construct a wide-field NIR camera on Subaru, and in this research, we will actually build such camera with the largest field of view.

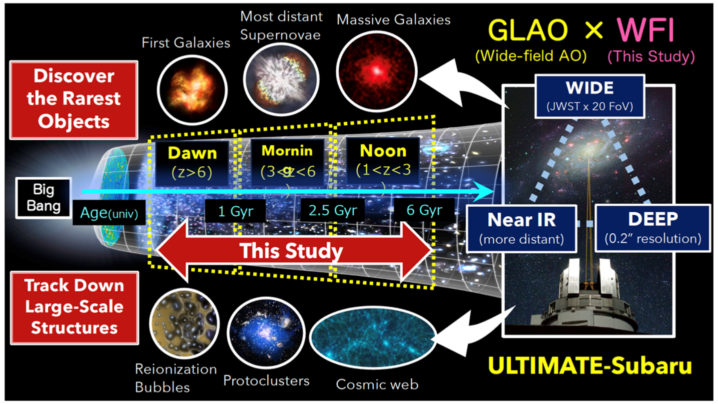

Figure 1. Concept of the research

●Construction of wide-field NIR camera (WFI)

The NIR wide-field camera to be built on Subaru will transform the current Subaru to the "ULTIMATE" Subaru. National astronomical observatory of Japan (NAOJ) is now developing a wide-field adaptive optical system (GLAO) on Subaru to be completed in 2028 as a MEXT frontier project, which will deliver the space telescope quality high resolution images across the largest field. We will make best use of this new capability with WFI fully covering this wide field. WFI provides the largest FoV among ground-based telescopes and is 20 times larger than JWST (Fig. 2).

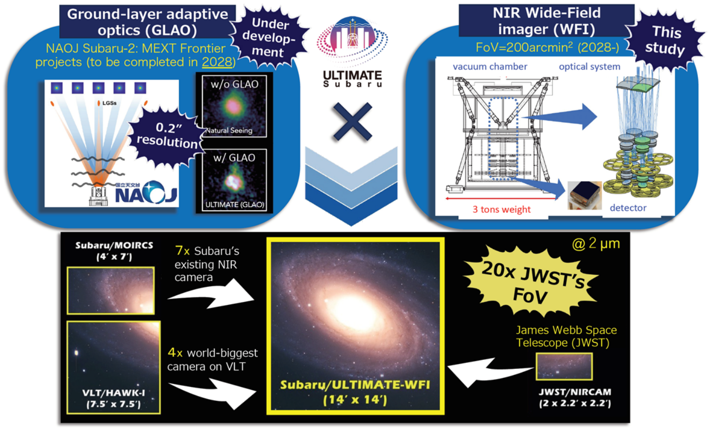

Figure 2. Conceptual design of WFI

●Uniqueness of our research

The next generation space telescopes include Euclid launched in 2023, and Roman to be launched in 2026. They will both conduct wide-field observations, but the available filters are limited to broad-bands as shown in Fig. 3. We plan to make 10 medium and 6 narrow band filters on WFI, extending up to 2.4 μm. This unique suite of filters will provide us with opportunities to conduct unique wide-field imaging surveys of the early Universe (see below). Subaru actually conducts coordinated synergy programs in collaborations with those space telescopes to complement capabilities.

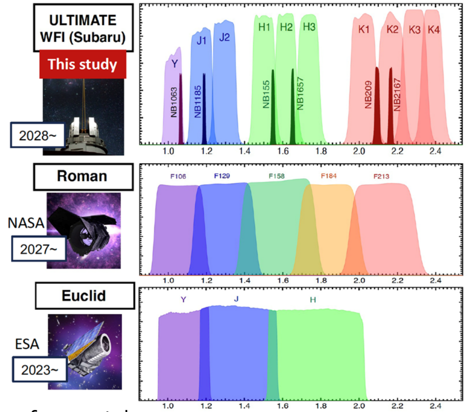

Figure 3. Filters to be made for WFI, compared to those of space telescopes

Expected Research Achievements

●3 major science goals (Fig. 4)

【Cosmic reionization】 Afte the Big-bang, the ionized hydrogen is recombined as it cools by cosmic expansion. As the first generation of objects are formed, hydrogen is ionized again due to UV radiation from young stars. The ionized regions are expanding around galaxy structures and eventually fully ionized (Fig. 5). This process can be tested by HI gas mapped by narrow-band imaging of Lyα emitters, since Lyα photons are attenuated by associated HI gas, and can be seen only through the ionized bubbles.

【Massive galaxies】 Standard galaxy formation models predict that massive galaxies are formed through merging of small galaxies formed earlier. Massive galaxies must be very rare in the early Universe. Thus, finding those galaxies can offer the critical test for the bottom-up theory of galaxy formation and thus standard cold-matter cosmology. Medium-band filters play key roles here to find and identify those massive galaxies.

【New supernova】 Recent observations have revealed more metals in the early Universe than predicted. This mystery can be solved if a new type of supernova exists which produces a lot of metals from the first generation of stars. We aim to find such supernova for the first time by a wide-field transient survey with medium-band filters.

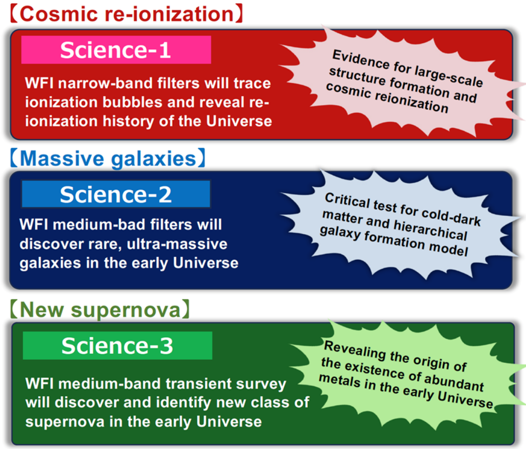

Figure 4. Three major science goals

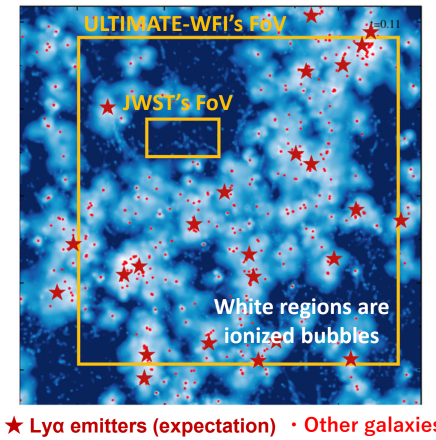

Figure 5. Ionizing bubbles at the cosmic reionization epoch (z~8)

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