W. M. KECK OBSERVATORY
Maunakea, Island of Hawaiʻi

The Keck Cosmic Reionization Mapper

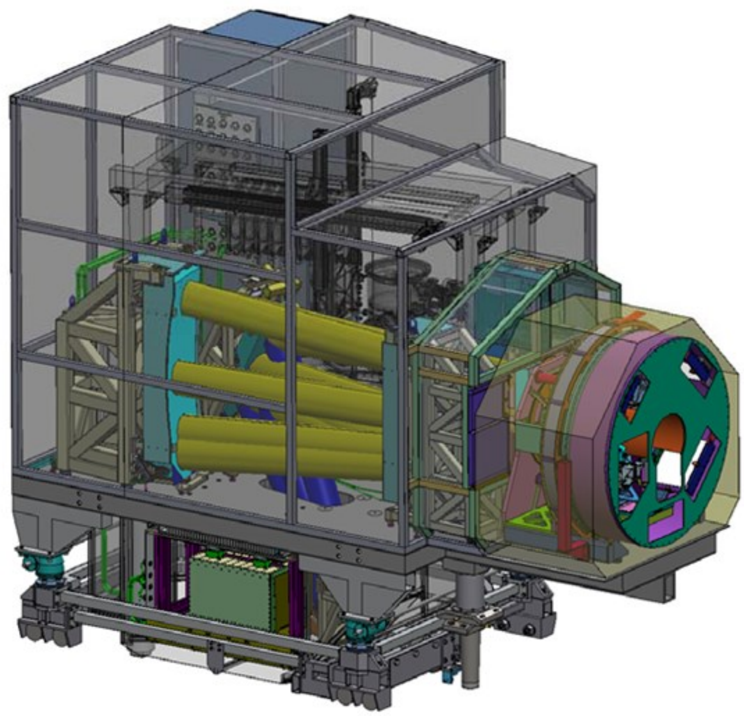

Illustration of the Keck Cosmic Reionization Mapper
CREDIT: WMKO

The Keck Cosmic Reionization Mapper (KCRM) is an instrument designed to image the vast web of gas that connects galaxies in the universe. This instrument will be one of the best instruments in the world for taking spectral images of cosmic objects - detailed images where each pixel can be viewed in all wavelengths of visible light. Such high-resolution spectral information will enable astronomers to study the compositions, velocities, and masses of many objects, such as stars and galaxies, in ways that were not possible before.

KCRM will be used to study what is called the cosmic web - a vast network of streams of gas between galaxies. Recently, scientists have found evidence supporting what is called the cold flow model, in which gas funnels into the cores of galaxies, where it condenses and forms new stars. Researchers had previously predicted that the gas filaments would first flow into a large ring-like structure around the galaxy before spiraling into it.

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With KCRM, researchers will get a closer look at the gas filaments and ring-like structures around galaxies that range from 10 to 12 billion light-years away, an era when our universe was roughly 2 to 4 billion years old.

KCRM will map the gas flowing from the intergalactic medium - the space between galaxies - into many young galaxies, revealing, for the first time, the dominant mode of galaxy formation in the early universe. The instrument will also search for supergalactic winds from galaxies that drive gas back into the intergalactic medium. How gas flows into and out of forming galaxies is the central open question in the formation of cosmic structures.

KCRM will also be used in other areas of astrophysics. It will study everything from gas jets around young stars to the winds of dead stars and supermassive black holes and more.

Key Capabilities:

A core feature of KCRM will be its ability to capture spectral information about objects, such as galaxies, for every pixel in an image. Typically, astronomers capture spectra using instruments called spectrographs, which have narrow slit-shaped windows. The spectrograph breaks apart light from the slit into each of the colors making up the target object, just like a prism that spreads light into a rainbow. But traditional spectrographs cannot capture spectral information across an entire image.

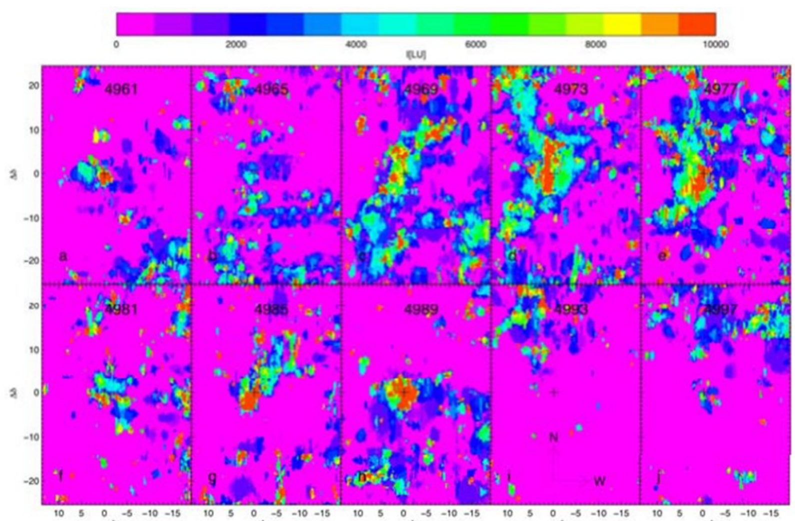
To create a spectrograph that can also image more extended objects like galaxies, KCRM uses what is called an integral field design, which basically divides an image up into 24 slits, and gathers both the spectral and spatial information at once.

KCRM has the highest spectral resolution of any integral field spectrograph, which means it provides a more detailed view of the spectrum. The first phase of the instrument, now at Keck, covers the blue side of the visible spectrum, spanning wavelength ranges from 3,500 to 5,600 angstroms and is called KCWI-Blue. KCRM is the second phase, extending coverage to the red side of the spectrum, out to 10,400 angstroms and will be built in the next few years. The combination of these improvements with the fact that Keck Cosmic Web Imager (KCWI) is being installed at one of the twin 10-meter Keck telescopes - the world's largest observatory with some of the best skies for observing on Earth - means that KCRM will have an improved performance by more than an order of magnitude better than previously built instruments.

The KCWI instrument (KCWI-Blue + KCRM) when complete will be about the size of an ice cream truck and will weigh about 9000 lbs. Currently KCWI-Blue is being installed and commissioned onto Keck II. KCRM will take about 3 years to build and then will be integrated with KCWI-Blue. When the integration is complete the finished instrument will be called KCWI.

KCRM and Galaxy Evolution:

The Keck Cosmic Reionization Mapper (KCRM) will help us understand and explain the amazing diversity of galaxies, the Circum-Galactic Medium (CGM) (which is the interface between the interstellar medium of galaxies and the Inter-Galactic Medium (IGM)) and the Cosmic Web that we observe in the universe today. By looking back in time to epochs where matter was just starting to re-ionize, a time before galaxies had formed. KCRM will help us to understand how galaxies have changed through time since the Big Bang and how the gas and temperature around those galaxies has changed. Reionization is the process that re-ionized the matter in the universe 150 million years after the Big Bang. Re-ionization is a phase transition of hydrogen gas in the universe.



Circum-Galactic Medium and the Cosmic Web
CREDIT: WMKO

How galaxies get their gas is one of the central questions in galaxy evolution today. There is a theory that during the period when galaxies were being formed into protodisks and star formation was occurring within the galaxies, the cosmic web was fueling cold streams of gas directly into galaxy protodisks. KCRM could provide the first direct images of cold flows of gas if they emit via scattered Lyα, which is a spectral line of hydrogen that is detectable by KCRM.

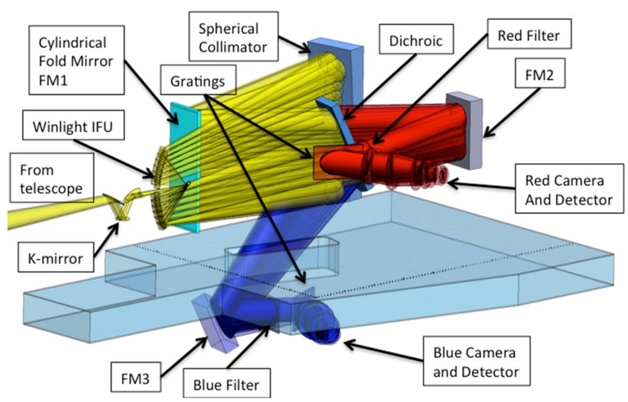
Left: Galaxy Images
CREDIT: GALAXY ZOO BLOG

Right: Cosmic Web Image
CREDIT: INSTITUTE OF SCIENCE IN SOCIETY

KCRM and the Nature of Dark Matter:

Dark matter is an unidentified type of matter that has not been directly detected but its existence and properties are inferred from its gravitational effects on luminous matter such as the measured velocities of visible matter (like stars) around the centers of galaxies. Dark matter is a huge mystery in physics and astronomy. Dark Matter is estimated to make up ~85% of the total mass in the universe.

Low mass galaxies are often dark matter dominated, and provide a unique opportunity to probe the distribution of dark matter and test dark matter models. A long-standing problem for these models that can be investigated with KCRM is the lack of the "cusps" predicted in galaxy cores if the dark matter is cold and not self-interacting. The lack of cusps is a discrepancy between the observed dark matter density profiles of low-mass galaxies and the density profiles predicted by cosmological simulations which show cusps. High spectral resolution and low surface brightness spectral mapping by KCRM will be a uniquely powerful probe for addressing this problem.



KCWI Isometric Opto-Mechanical Layout (KCRM is the Red Optical Design in the Schematic)
CREDIT: WMKO

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The W. M. Keck Observatory operates the largest, most scientifically productive telescopes on Earth. The two, 10-meter optical/infrared telescopes near the summit of Mauna Kea on the Island of Hawai'i feature a suite of advanced instruments including imagers, multi-object spectrographs, high-resolution spectrographs, integral-field spectrographs and world-leading laser guide star adaptive optics systems. Keck Observatory is a private 501(c) 3 non-profit organization and a scientific partnership of the California Institute of Technology, the University of California and NASA. For additional information about W. M. Keck Observatory, please visit http://www.keckobservatory.org/.