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The COSMOS 2-degree HST/ACS survey ☆

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Abstract

The COSMOS survey is the largest contiguous imaging project ever undertaken with the Hubble Space Telescope, using ACS/WFC to image a 2 square degree low-background equatorial field in 600 orbits with the F814W (I) filter. The survey is providing over 2 million objects with a 10σ detection limit AB(I) < 27, with a sky coverage of 10 billion ACS pixels at a scale of 50 milliarcseconds/pixel. The principal goal of the project is to probe the formation and evolution of structures with size scales from galaxies to Coma-size clusters during the peak period of galaxy, AGN and star formation activity (redshifts $\sim$0.5–3). The first half of the Cycle 12 data are now in hand, and some of the main preliminary science results from these data will be discussed. Two of the main scientific drivers for the project are to map the distribution of large scale structure in dark matter through weak lensing, and to measure the evolution of galaxies in the context of large scale structure. In addition, the large area of the survey is serving a wealth of other science topics, including comparatively rare high-luminosity AGN, starbursts and extremely red galaxies at high redshift. Combined with a wide range of ancillary datasets from X-ray through radio, this survey is becoming a truly unique Hubble legacy for understanding the evolution of the visible and dark universe.
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Keywords: Cosmology: observations; Cosmology: dark matter; Cosmology: large-scale structure of universe; Galaxies: evolution; Surveys

Contents

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1. Introduction

A principal goal of observational cosmology is to trace the history of star formation and active galactic nuclei (AGN), along with the mass assembly history of galaxies, as a function of redshift and environment over the age of the universe. While the rate of galaxy evolution and the morphological mix of galaxies are thought to be strongly dependent upon the local density in the large scale structure (LSS), this is well established only in the nearby universe, through surveys such as the 2dF and SDSS. Since galaxy interactions drive much of the activity in the early universe, it is therefore crucial to sample the full range of overdensities in the LSS environment at all redshifts, up to and including $z \sim 1$–3 where the apparent peak in star formation activity occurs.

In addition to covering a sufficiently large area to sample the full range of LSS, it is also important to obtain sufficient angular resolution to resolve galaxies at the redshifts of interest on sub-kiloparsec scales, to allow sufficiently detailed study of their morphology. This also enables measurements of weak lensing to be carried out with great accuracy, thereby providing direct mass maps of the underlying overdensities. The COSMOS survey is specifically designed to address these questions by obtaining nearly 600 orbits of imaging with the Hubble Space Telescope (HST) Advanced Camera for Surveys (ACS) over an area of about 2 square degrees.

2. Scientific design

The fundamental design of the COSMOS survey aims to be able to cover a comoving volume similar to that sampled by the SDSS, corresponding to about 150 Mpc on a side, at redshifts of 2–3 when starformation activity was at its peak. This is sufficient to sample all scales currently envisaged for LSS, up to masses $\geqslant 2 \times 10^{14} M_{\odot}$. In addition, the sensitivity of the observations reaches to 10σ detection limits of AB(I) ~ 27, sufficient to fully characterize the morphology, multiplicity and interactions of L^* galaxies out to $z \sim 2$–3.

The area of 2 square degrees is covered using the ACS/WFC detectors, spending a total of one orbit on each pointing (2400s), divided into four sub-exposures that are dithered to improve PSF sampling and eliminate cosmic rays and bad pixels. The ACS/WFC camera consists of two detectors, each of which is 2048×4096 pixels at $0.05''$/pixel, thus covering a field of view of $\sim 3'$. Imaging the full 2 square degrees therefore requires a grid of about 24×24 pointings, corresponding to a total extent of $\sim 1.4^\circ \times 1.4^\circ$, and sampling the sky with $\sim 10^{10}$ pixels, each 50 milliarcseconds in size (see Fig. 1).

The COSMOS observations form the largest contiguous area ever observed with HST, and in fact are so extensive that they had to be divided between Cycles 12 and 13, in addition to having forced a pointing change because of irreconcilable scheduling problems arising from the initial pointing. As of May 2004, all the Cycle 12 data have been obtained, covering the central $\sim 1^\circ \times 1^\circ$, thereby already making this project the largest contiguous area ever observed by HST.

In addition to the HST data, the project also includes significant investments of time from other facilities including Subaru, VLT, VLA, XMM, and other related proposals submitted to Chandra and Spitzer. The final survey will provide a wealth of data on over 2 million galaxies, including several thousand X-ray emitting AGN, at least 100 X-ray clusters, and samples of several tens of thousands of Lyman break galaxies, EROS, and other red galaxies at high redshift, in addition to the detailed maps of dark matter and LSS.

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