DEEP: NEW SURVEYS OF DISTANT FIELD GALAXIES

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RESUMEN

Describimos el proyecto DEEP, un estudio en dos fases (DEEP1, DEEP2) con el objectivo de caracterizar las propiedades de galaxias lejanas del campo. Para esto utilizamos datos espectrales obtenidos con los Telescopios Keck, de los cuales medimos la cinemática interna de galaxias, y imagenes HST. Con el DEEP, aspiramos caracterizar la formacíon y evolucíon de galaxias, mapear las estructuras de larga escala lejanas, y imponer mejores restricciones sobre los modelos cosmológicos. Aquíse discuten los principales resultados del DEEP1.

ABSTRACT

We outline the DEEP project, which is a two-part (DEEP1, DEEP2) spectral survey of faint field galaxies with the Keck Telescopes. The data include internal kinematics of galaxies and *HST* imaging. The scientific goals include tracking galaxy formation and evolution , mapping distant large scale structures, and constraining cosmology. DEEP1 highlights are summarized.

Key Words: **COSMOLOGY: OBSERVATIONS — GALAXIES: EVOLUTION — GALAXIES: FUNDAMENTAL PARAMETERS — GALAXIES: KINEMATICS**

1. WHAT IS DEEP?

DEEP was initiated over 10 years ago as a major spectral survey of faint field galaxies using the Keck 10 m Telescopes. The use of DEIMOS[3] divides DEEP into two parts (see Table 1). The first (DEEP1) includes several pilot surveys of 10's to 100's of galaxies using pre-DEIMOS spectrographs on Keck I and II. DEEP1 was designed to determine the technical feasibility and scientific scope of DEEP2, a DEIMOS survey of 50,000 galaxies that starts in mid-2002. DEEP1 covered fields with HST WFPC2 images, which provide not only morphology and photometry but also structure, size, and inclination data needed to convert kinematics from Keck spectra into direct measures of dynamical mass.

DEEP is distinguished by its large sample size, depth, and quality. One reason for having large numbers is that galaxy evolution involves a complex interplay of diverse galaxy classes, environments, and physical mechanisms. The other is that precision cosmology via the volume test or velocity functions requires averaging over the fluctuations due to large-scale clustering. The depth of $I \sim 23-24$ reaches typical galaxies at redshifts $z \sim 1$. The spectral quality is good enough to yield rotation curves, linewidths, and line strengths sensitive to star formation rates, gas conditions, stellar-population ages, and metallicity. Supplementing counts, colors, luminosities, and clustering properties of distant galaxies, these new measures provide independent probes of galaxy properties that have clear links to theoretical simulations of galaxy formation.

2. DEEP1 HIGHLIGHTS & SUMMARY

The main theme that arises from our DEEP1 results is that galaxy evolution is a complicated problem. Distant field galaxies are diverse in size, luminosity, structure; are composed of subcomponents which experience different star formation and dynamical histories and evolution; and reside in a wide range of environments likely to involve different physical mechanisms for their evolution. We have established that kinematics are both feasible with 10 m class telescopes and valuable for understanding distant galaxies. For spirals, we find relatively little evolution in the Tully-Fisher relation (Vogt et al. 1996,1997,2002b) or disk surface brightness (Simard et al. 1999) to redshifts $z \sim 1$. In contrast, for spheroidals at the same epoch, we find strong evidence for luminosity evolution in the fundamental plane (Gebhardt et al. 2002) and luminosity function (Im et al. 2002), but little change in volume density (Im et al. 2002). Using the DEEP1 data in the GSS field (see Table 1 and Vogt et al. 2002a; Simard et al. 2002; Phillips et al. 2002), the colors of spheroidal galaxies (Koo et al. 1996; Im et al. 2001,2002; Gebhardt et al. 2002) and bulges are, however, redder than expected and thus a puzzle (Koo et al. 2002).

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[2] DEEP: Deep Extragalactic Evolutionary Probe; see participants and addresses at URL: **http://deep.ucolick.org/**

[3] DEIMOS: DEep Imaging Multi-Object Spectrograph (Davis & Faber 1998); more information is provided at URL: **http://www.ucolick.org/ ~loen/Deimos/deimos.html**

TABLE 1

DEEP SURVEY CHARACTERISTICS

···	DEEP1	DEEP2
Telescopes	Keck I,II; HST	Keck II
Instruments [a]	LRIS, ESI, HIRES, NIRSPEC	DEIMOS
Survey Period (Keck)	1995-2001 (30 Nights)	2002-2004 (120 Nights)
Fields [b](FOV)	HDF-N&FF ($8' \times 8'$)	0230+00 ($30' \times 120'$)
···	GSS 1417+52 ($4' \times 42'$)	1417+52 ($16' \times 120'$)
···	SA68 0017+15 (five $4' \times 7'$)	1652+35 ($30' \times 120'$)
···	···	2330+00 ($30' \times 120'$)
No. Galx. & Depth (expos.)	1000 to $I \sim 23.5$ (1-4h)	1HS: 50,000 to $I \sim 23$ (1h)
···	···	3HS: 5,000 to $I \sim 24$ (3-10h)
Photometry	KPNO ($UBRI$); HST(VI)	UH (BRI); HST(TBD)
Science	Spheroid/Bulge Evol.	1HS: includes DEEP1 Science
···	Disk Surface Brightness Evol.	& Clustering Evol. at z $\sim$ 1
···	Compact & High z Galaxy Evol.	& Lum. Funct. (color, z, velocity)
···	Tully Fisher & Fund. Plane Evol.	& Volume Test (Dark Energy)
···	AGN/Variability/Lum. Funct.	3HS: includes DEEP1 Science
···	Star Formation & Chem. Abund. Evol.	& Red Galaxy Age & Metallicity

[a]LRIS: Low Resolution Imaging Spectrograph; ESI: Echelle Spectrograph Imager; HIRES: High Resolution Echelle Spectrograph; NIRSPEC: Near Infrared Spectrograph; DEIMOS: DEep Imaging Multi-Object Spectrograph

[b]HDF: Hubble Deep Field; FF: HDF Flanking Fields; GSS: Groth Strip Survey; SA68: Selected Area 68

On the other hand, luminous blue compact galaxies, whether at low redshifts $z < 1$ (Phillips et al. 1997) or at high redshifts $z \sim 3$ (Lowenthal et al. 1997), appear to have very low dynamical masses and are thus suggested to be possible progenitors of quiescent low-mass spheroidals today (Koo et al. 1995; Guzmán et al. 1996, 1997) or the building blocks of larger galaxies rather than massive ellipticals undergoing formation via monolithic collapse (Steidel et al. 1996). Additional studies of the chemical evolution (Kobulnicky et al. 2002), ages of distant red galaxies (Schiavon et al. 2002), AGN activity (Sarajedini et al. 2002), general luminosity functions (Willmer et al. 2002), and velocity widths (Weiner et al. 2002; Phillips et al. 2002) are being completed and should provide a broader view of the evolution of field galaxies at redshifts $z \sim 1$.

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