Answer to the CFHT-MegaPrime call for ideas

A MEGAPRIME Survey: Mapping the large scale structures and the evolution of galaxies on 100 deg$^2$

**Summary**: Mapping the large scale structures in the universe and understanding the evolution of galaxies and AGNs therein has been a constant focus of observational cosmology over the past 30 years. We are proposing to continue to expand our knowledge of the evolution of structures from galaxies up to the largest superclusters of several hundred Mpc in extent: a multi-color survey of $\sim 100$deg$^2$ at a depth $AB = 25$ ($5\sigma$ in a 3 arcsec aperture; or $AB \sim 26.2$ for point sources) would be a unique endeavour in the history of astronomy. More than 20 million galaxies and $10^9$ QSOs would be detected in 2 fields each $10 \times 5$deg$^2$, providing unique data for many prime scientific objectives. This would require **100 nights**.

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**Scientific Justification** In 2001, several imaging surveys each covering $\sim 20$deg$^2$ to a depth $AB \sim 25$ (at $5\sigma$ in a 3 arcsec aperture) will have been completed with the current generation of wide field imagers (CFH12K, Le Fèvre et al. on going survey; NOAO-cam), and the Sloan Digital Sky Survey will provide a survey of most of the Northern sky at a depth $AB \sim 24$ (point source). Going further requires to expand in field coverage: covering 100 deg$^2$ to $AB \sim 25$ would offer opportunities for statistical studies at high accuracies. A number of galactic and extragalactic science areas would greatly benefit from this dataset. We list below only some of the extragalactic science goals.

- **Large scale structure (LSS).** While we know much about the power-spectrum of density fluctuations at the present epoch and about structure growth to $z \sim 1$ in the non-linear regime ($r \leq 5h^{-1}$Mpc), very little is known about the growth of structure in the linear regime ($r$ up to $100h^{-1}$Mpc or more), where the growth term is directly related to $\Omega$. This survey will measure the amplitude of large scale structure clustering $\xi(r)$ at $z = 1 - 3$ with unprecedented precision. Photometric redshifts will be estimated for $5 \times 10^9$ galaxies with $I_{AB} < 24.0$ ($\sigma_I \leq 0.1$ mag in 3arcsec apertures), with a precision of $\sigma_z \leq 0.05$ for $0.3 < z < 1.0$, and $\sim 250000$ Lyman break galaxies. The large sample will enable to examine the dependence of clustering on luminosity and color.

- **Clusters at high redshift.** As the most massive bound objects in the U-
niverse, the evolution in the comoving space density of rich clusters at high redshift is a key test of the development of large scale structure and $\Omega$, but only a handful of clusters are known at $z > 0.6$. The survey sensitivity of $I_{AB} = 25$ ($5\sigma$, 3arcsec aperture) corresponds to $M^* + 2$ at $z \sim 1$ and is thus optimally matched to detection of clusters at this redshift. Probing to the highest redshifts is important: for the hottest clusters, the number of clusters deg$^{-2}$ varies for $0.3 < \Omega < 1.0$ by a factor of 5 for $z \leq 0.5$, but by a factor of 50 for $0.5 < z < 1.0$. Several hundred high redshift clusters are expected in this survey, their distribution in redshift will help constrain large scale structure evolution models.

- **Evolution of galaxies at $2.5 \leq z \leq 4.5$.** Using the Lyman break identification technique, this survey will identify $2.5 \times 10^5$ Lyman break galaxies (using the galaxy density observed by Steidel et al.). This will allow to compute the luminosity function and the evolution of the star formation rate over a sensitive redshift range, and establish their relationship to galaxy environment. The distribution of these galaxies in large scale structures is as yet unknown, although we have some indications of structures as seen in the redshift distribution (Steidel et al.). This survey would provide the numbers of galaxies and the angular coverage required for a detailed study of the clustering of these galaxies, as a function of luminosity, star formation rate, or local environment, on scales up to $\sim 100$Mpc.

- **AGNs evolution and space distribution:** about $10^5$ QSOs will be identified in this survey. The space density and luminosity function will be established from the photometric redshift determination. The distribution of QSOs will be used to trace the very large scale structures on supercluster scales.

**Related observations:** A redshift survey of $10^6$ galaxies to $AB = 22$ could be derived from this imaging survey. Redshift surveys of $\sim 10^5$ galaxies to this depth will take about 20 nights on 8m telescopes with instrumentation being build now (e.g. VIRMOS on the VLT). A redshift survey of $\sim 10^6$ galaxies is thus feasible if spread over several years. A complementary approach with existing or planned surveys at other wavelength should be sought for (XMM, Galex, VLA, SIRTF, etc.).

**Database requirements:** The amount of processed data will be $\sim 600$ Mby per camera pointing. 100 pointings with 6 filters will lead to science data $100 \times 6 \times 600$ Mby = 360Gby. Accomodating a database on order 1 Tby is required.

**Fields selection:** Fields should be equatorial to allow access from both hemispheres for further spectroscopic surveys. The CFH12K deep survey fields (Le Fèvre et al.), used as the basis to the VIRMOS redshift survey fields, could be
used as a starting point.

Survey Parameters: To reach a depth $AB \sim 25$ at $5\sigma$ in a 3 arcsecond aperture requires exposure times 2.5h, 1.5h, 1h, 1h, 1h, 1.2h in U, B, V, R, I, z resp. Note that the "5\sigma in a 3 arcsecond aperture" requirement stems for complete / unbiased galaxy samples: some authors quote fainter limits for the same exposure time, our values are based on experience acquired on our imaging surveys with successive imagers at CFHT (FOCAM, UH8K, CFH12K). Covering 100deg$^2$ requires $100 \times (2.5 + 1.5 + 1 + 1 + 1 + 1.2) = 820h$, or 100 nights with MegaPrime.