HOLOGRAPHIC DARK ENERGY AT THE RICCI SCALE

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Holographic Conjecture (`t Hooft, 1993)

It must be possible to describe all phenomena within V by a set of degrees of freedom which reside on the surface bounding V

Cohen et al. (1999) $L^3 \Lambda^3 \leq S_{BH}$

A more severe constraint imposes

$$L^3 \rho_X \leq L M_P^2 \qquad \rho_X = 3 M_P^2 c^2 L^{-2}$$

As infrared cutoff we take Ricci's length

$$L^{-2} \equiv R_{cc}^{-2} = \dot{H} + 2H^2$$

Evolution of the fractional densities

(Spatially flat FRW universe)

$$\dot{\Omega}_M - H\left(1 - \frac{2\Omega_X}{c^2}\right)(1-\Omega_X) = QH\,,$$

$$\dot{\Omega}_X + H\left(1 - \frac{2\Omega_X}{c^2}\right)(1-\Omega_X)\Omega_X = -QH$$

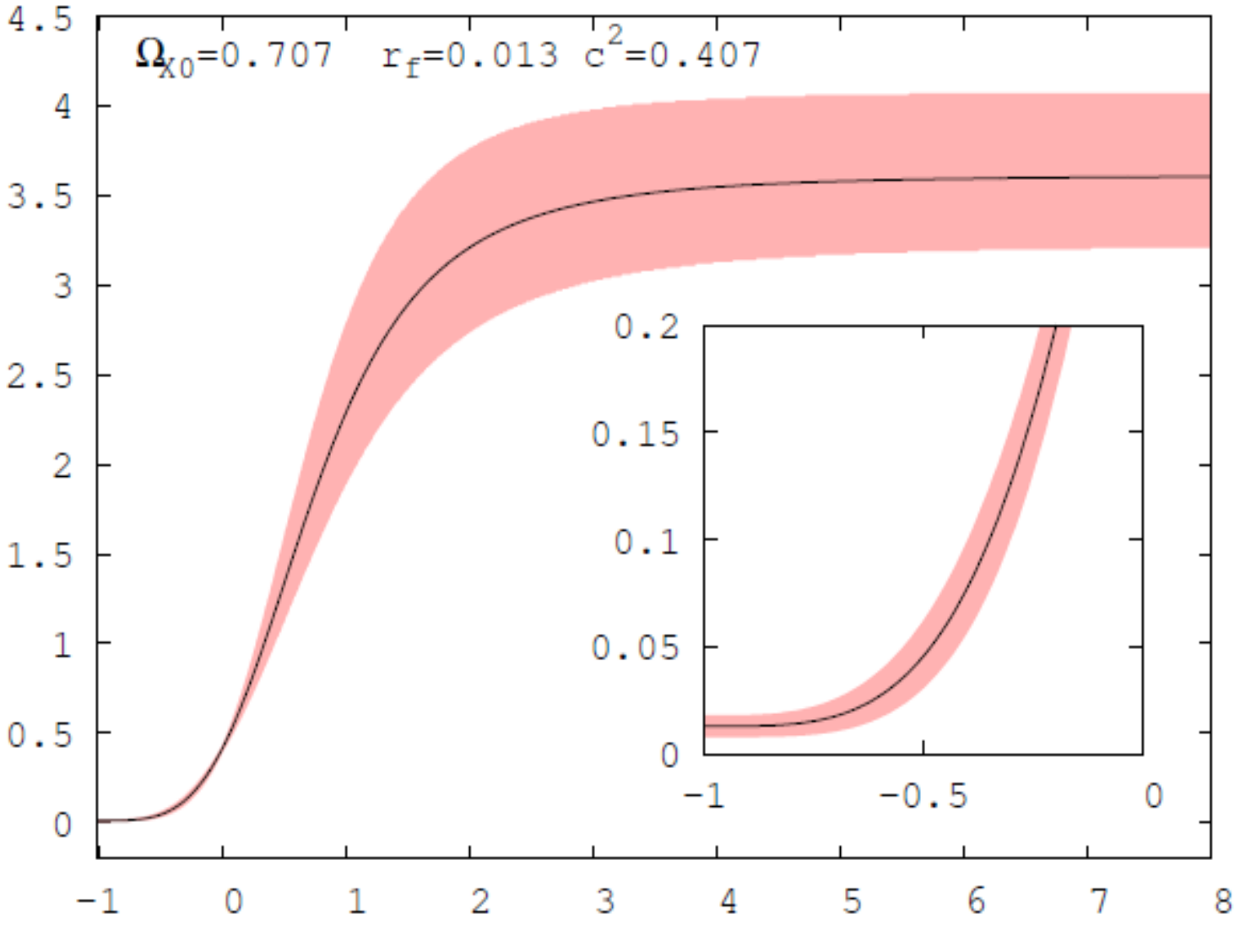
$$\Omega_M + \Omega_X = 1$$

$$\dot{r} = \left[r\left(1 + r - \frac{2}{c^2}\right) + Q(1+r)^2\right] H$$

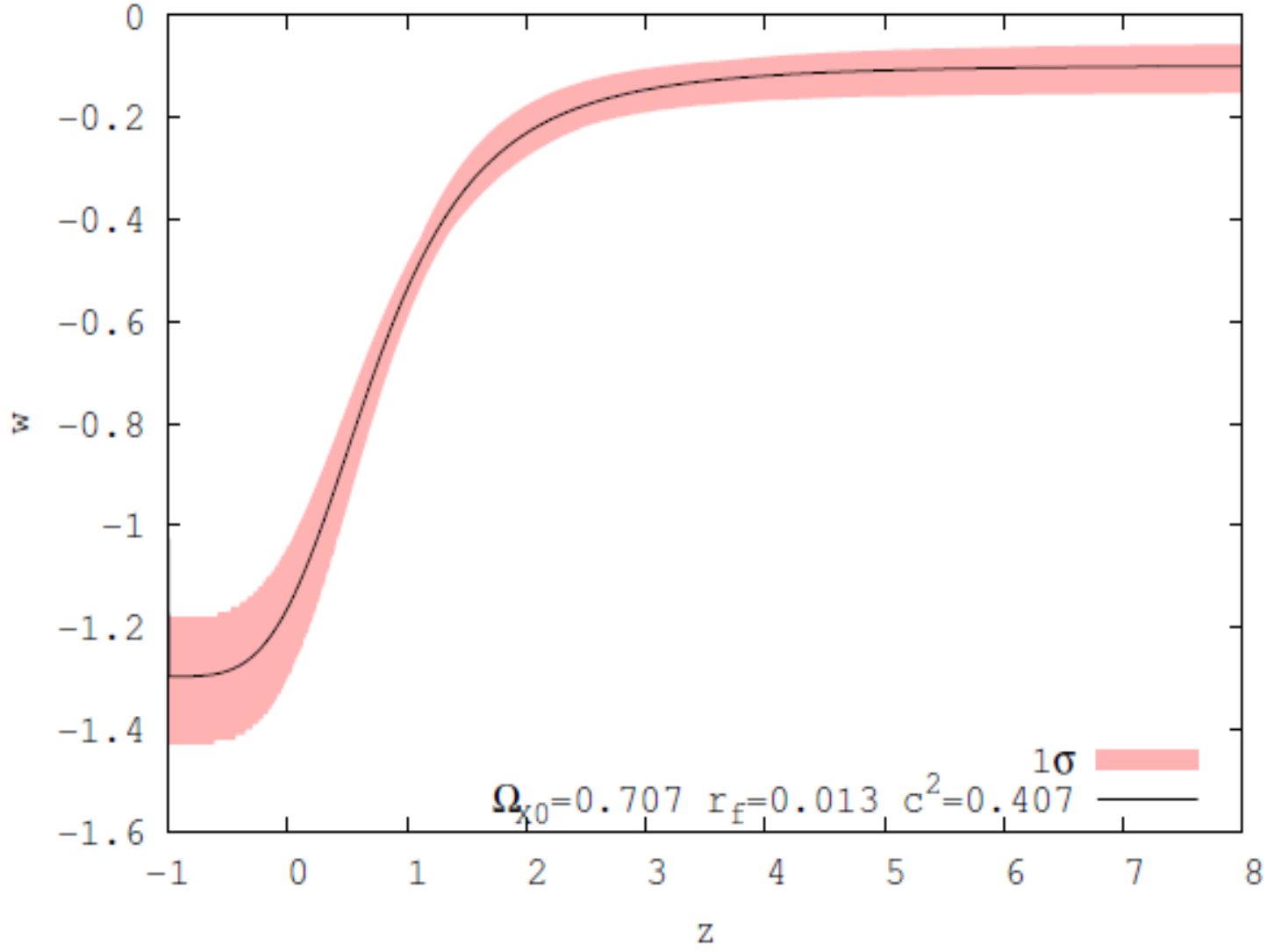
$$r \equiv \frac{\rho_M}{\rho_X}$$

$$Q = -\frac{r_f}{(1+r_f)^2}\left(1 + r_f - \frac{2}{c^2}\right)$$

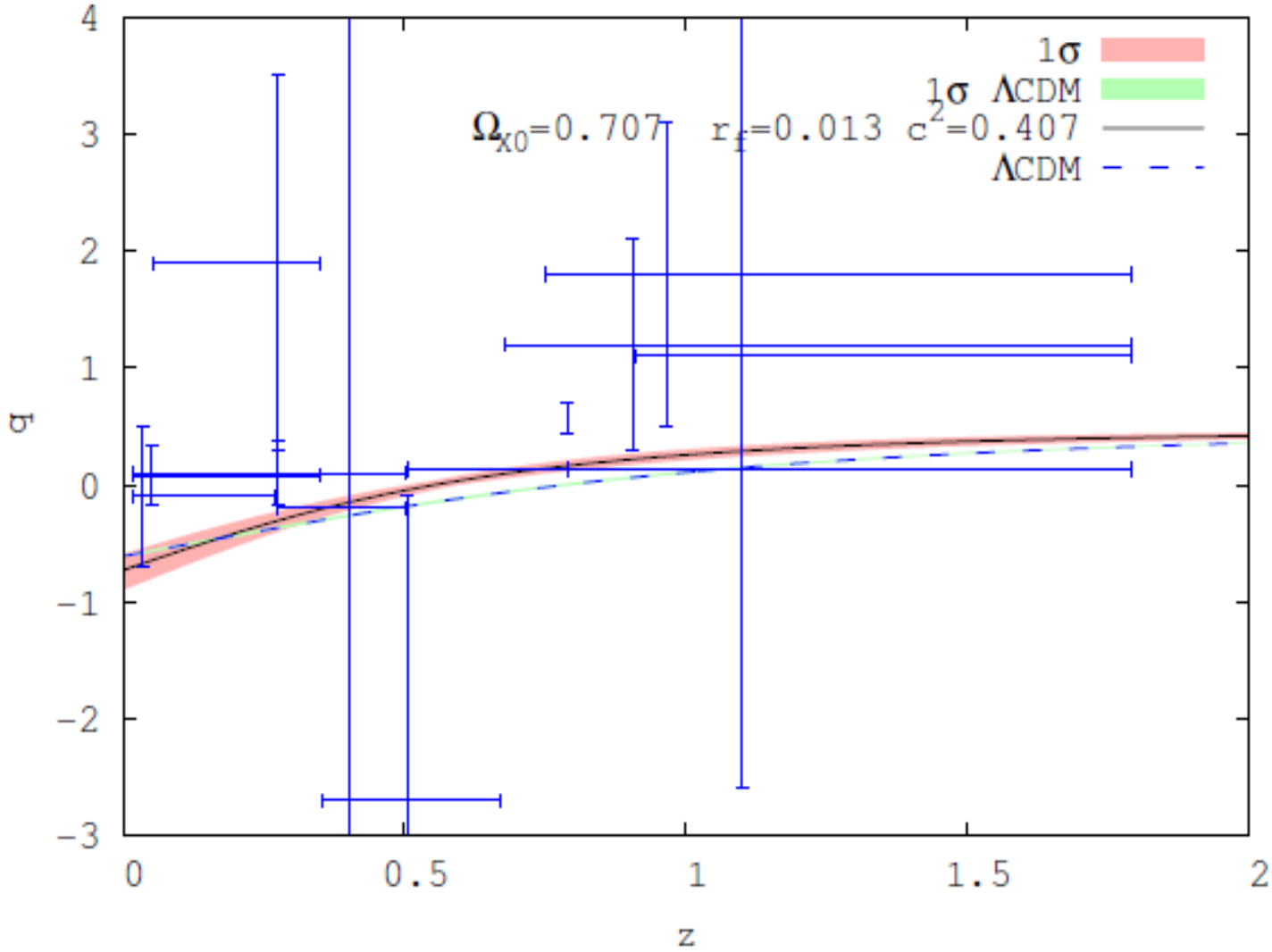
$$r \equiv \frac{\rho_M}{\rho_X}$$



Evolution of the ratio between the energy densitiesfor the best fit model. The cosmic coincidence problem gets much alleviated



Evolution of the equation of state parameter for the best fit model



Evolution of the deceleration parameter for the best fit models, holographic and LCDM

Free Parameters:

$$\Omega_{X0},\ c^2,\ r_f,\ \text{and}\ H_0$$

Constraints from:

- SN Ia, Union 2 Compilation, 557 data points
- CMB R-shift
- BAO
- Gas mass fraction in galaxy clusters, 42 data points
- History of the Hubble parameter, 15 data points
- Growth function, 5 data points

Shift of the first CMB peak

$$R = \sqrt{\Omega_{M_0}} \int_0^{z_{rec}} \frac{dz}{H(z)}$$

$$\mathcal{R}(z_{rec}) = 1.725 \pm 0.018$$

WMAP team (2009)

Best fit: $\mathcal{R}(z_{rec}) = 1.727 \pm 0.030$

Baryon acoustic oscillations

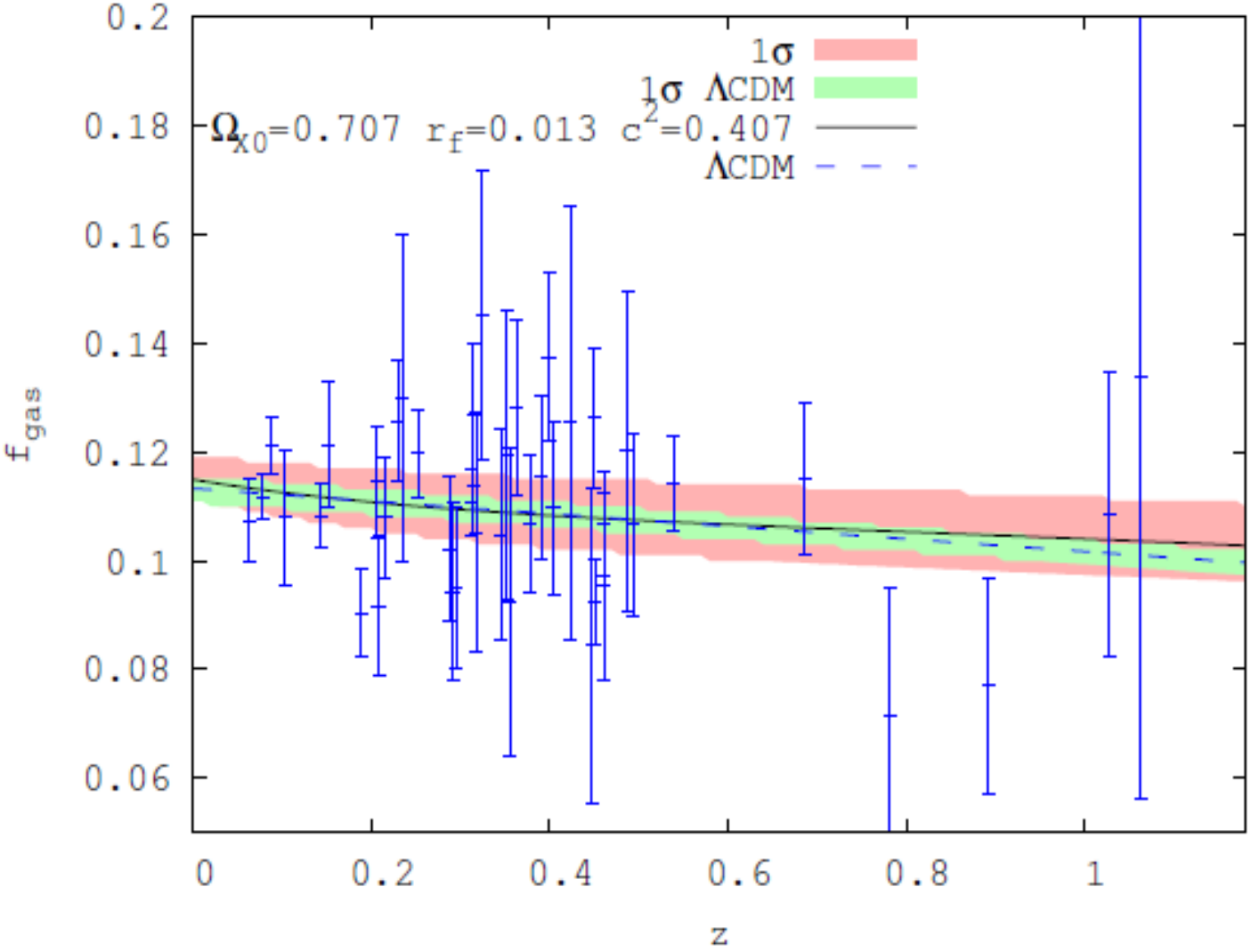
$$D_v(z) = \left[\frac{z}{H(z)} \left(\int_0^z \frac{dz}{H(z)} \right)^2 \right]^{\frac{1}{3}}$$

Z(BAO) = 0.35 & 0.2

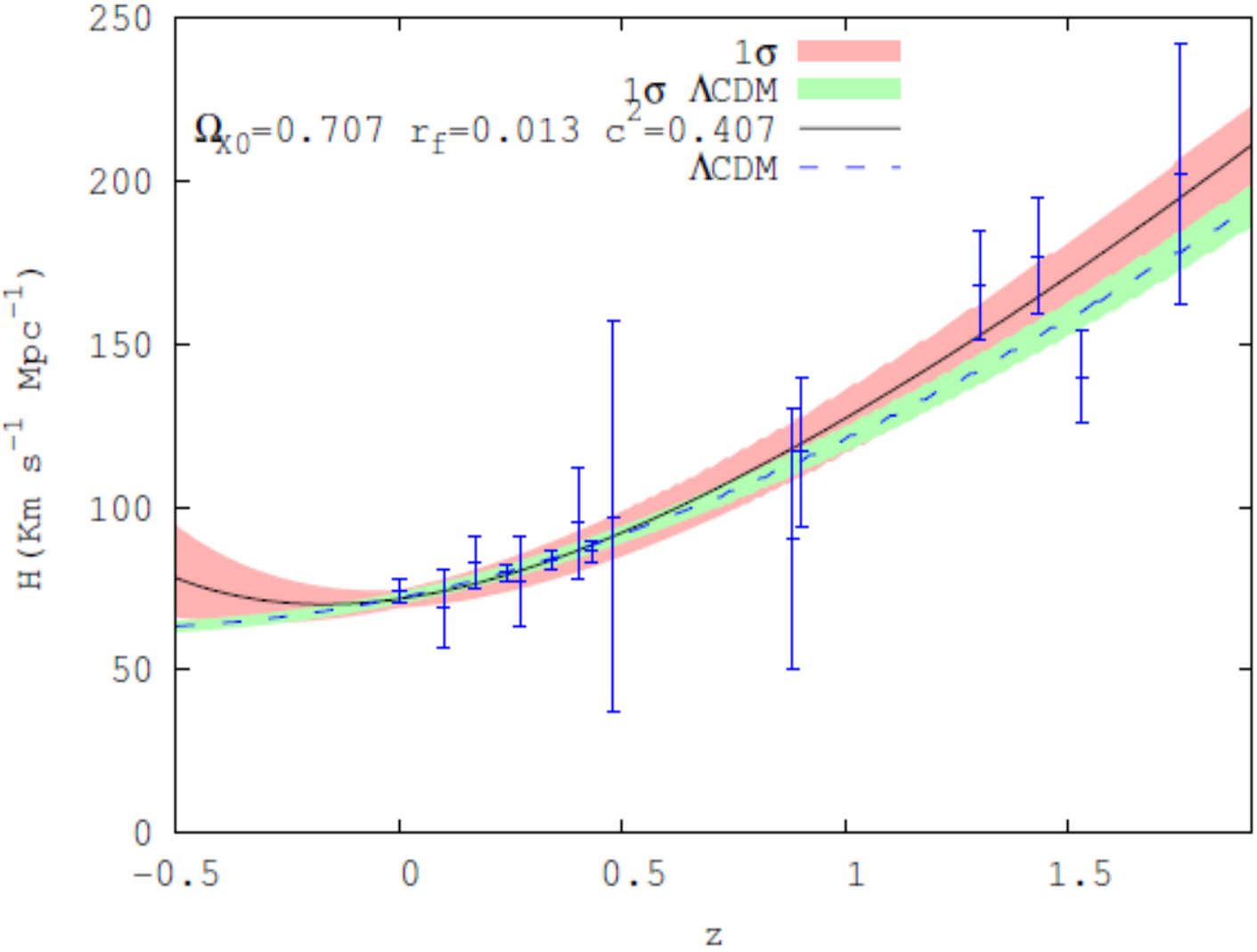
$$D_v(0.35)/D_v(0.2) = 1.736 \pm 0.065$$

Eisenstein et al (2005)
& Percival et al (2007)

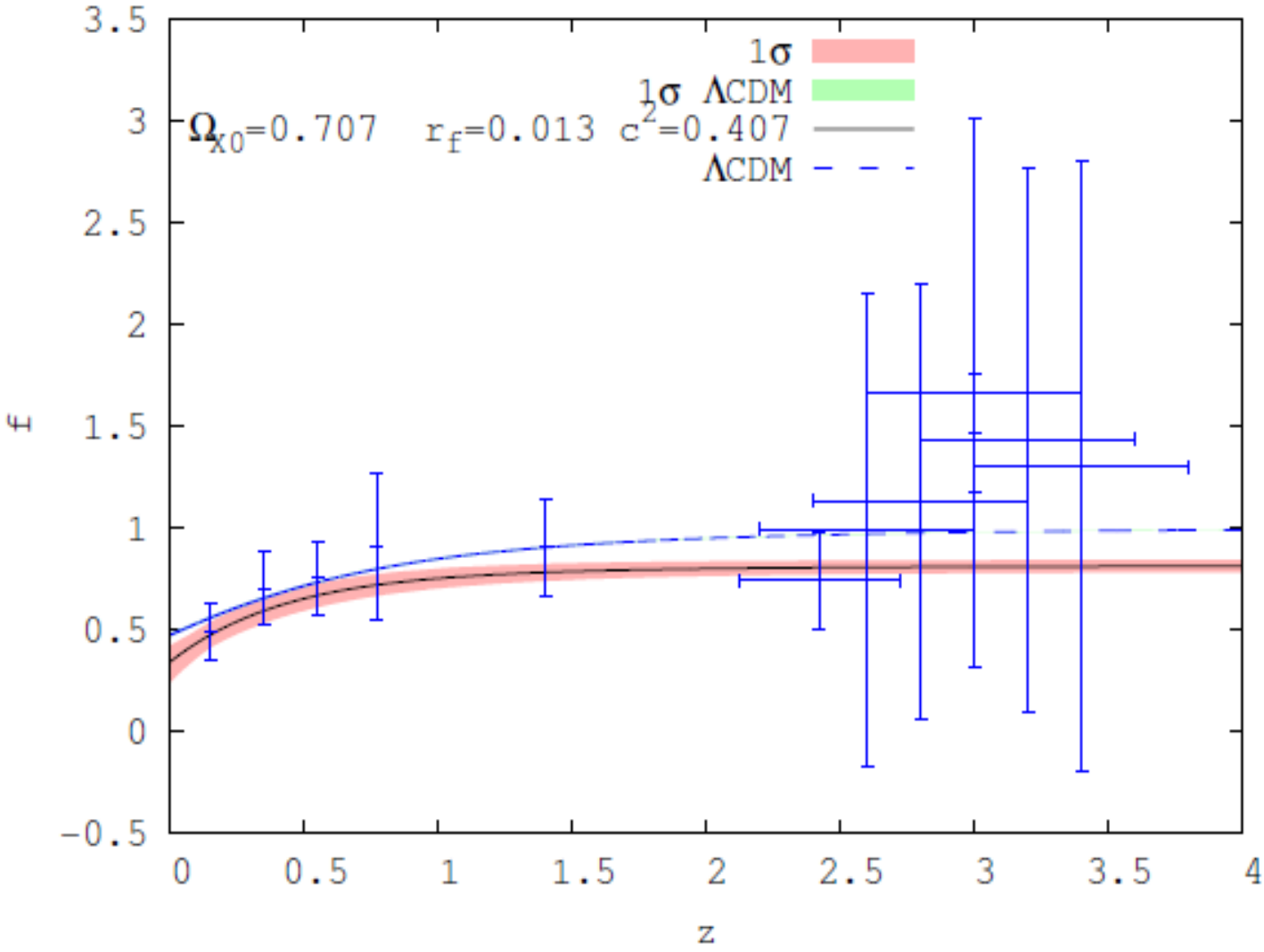
Best fit: $D_v(0.35)/D_v(0.2) = 1.664 \pm 0.003$



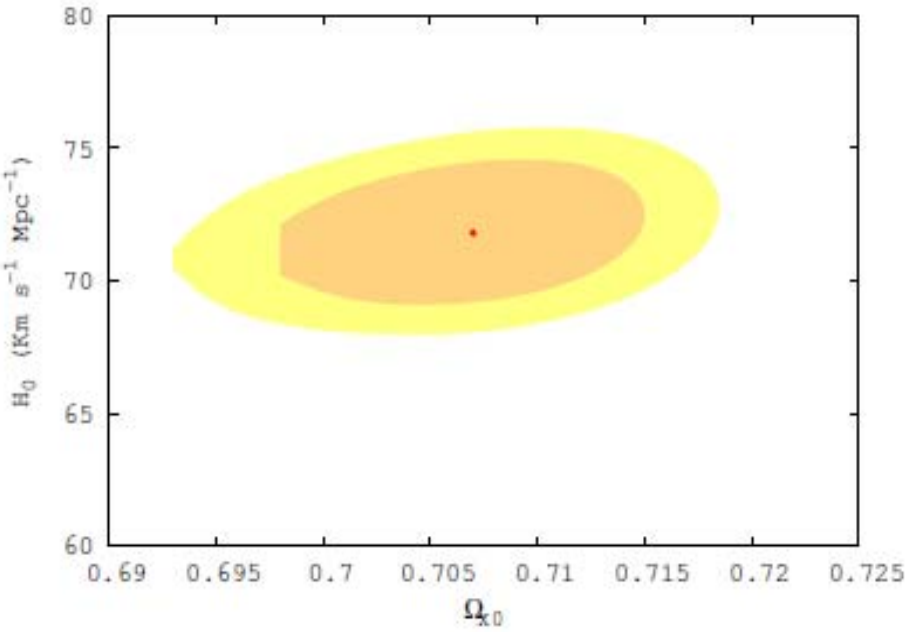
Gas mass fraction in 42 relaxed galaxy clusters vs. redshif
for the best fit models, holographic and LCDM

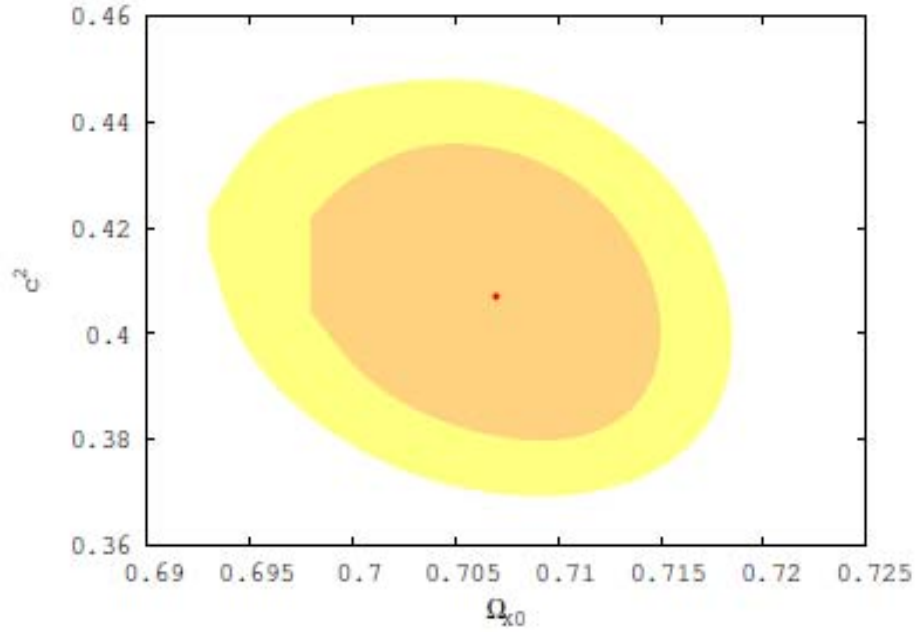


History of the Hubble parameter for the best fit models, holographic and LCDM

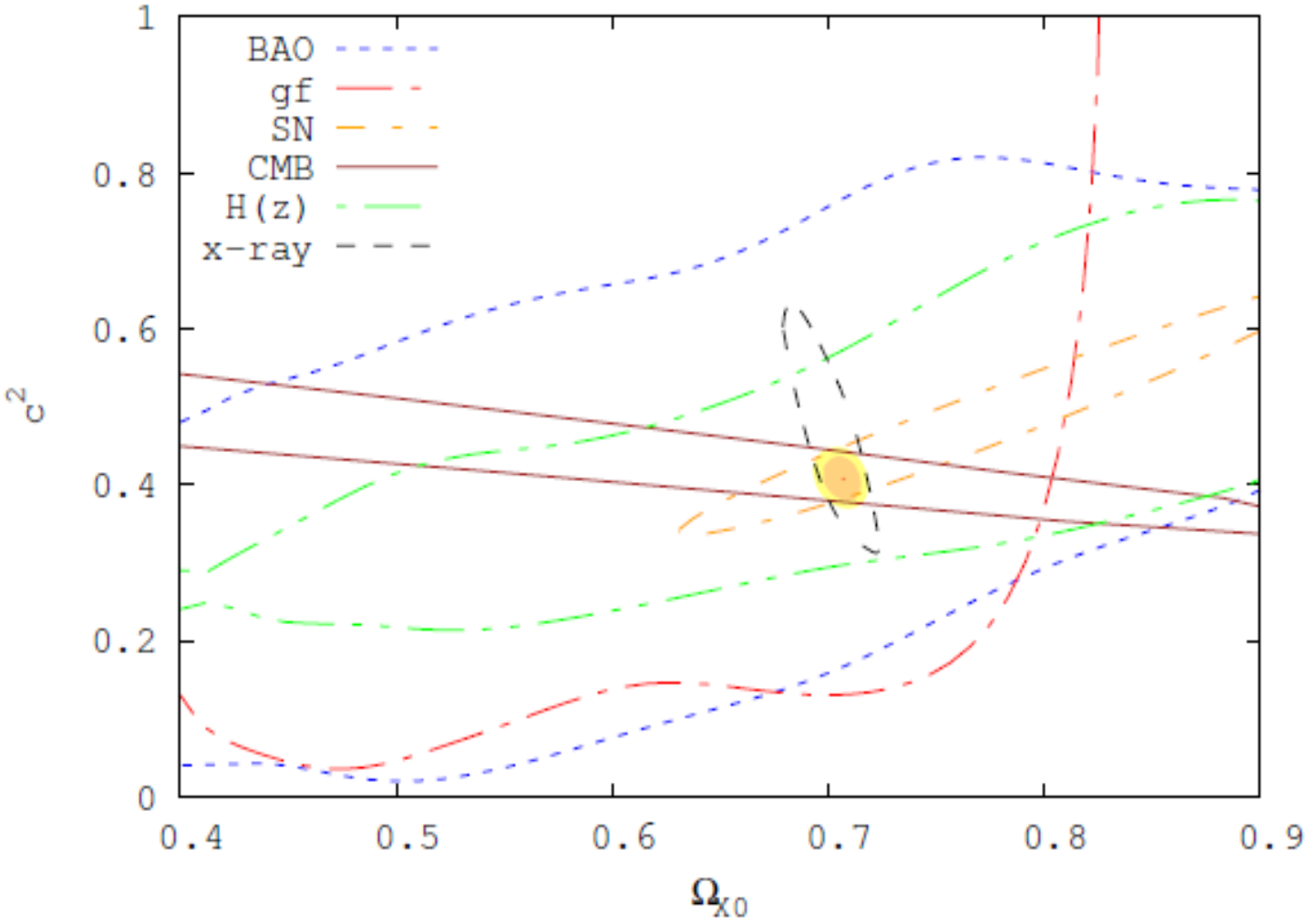


Growth function, f, in terms of the redshift for the best fit models, holographic and LCDM

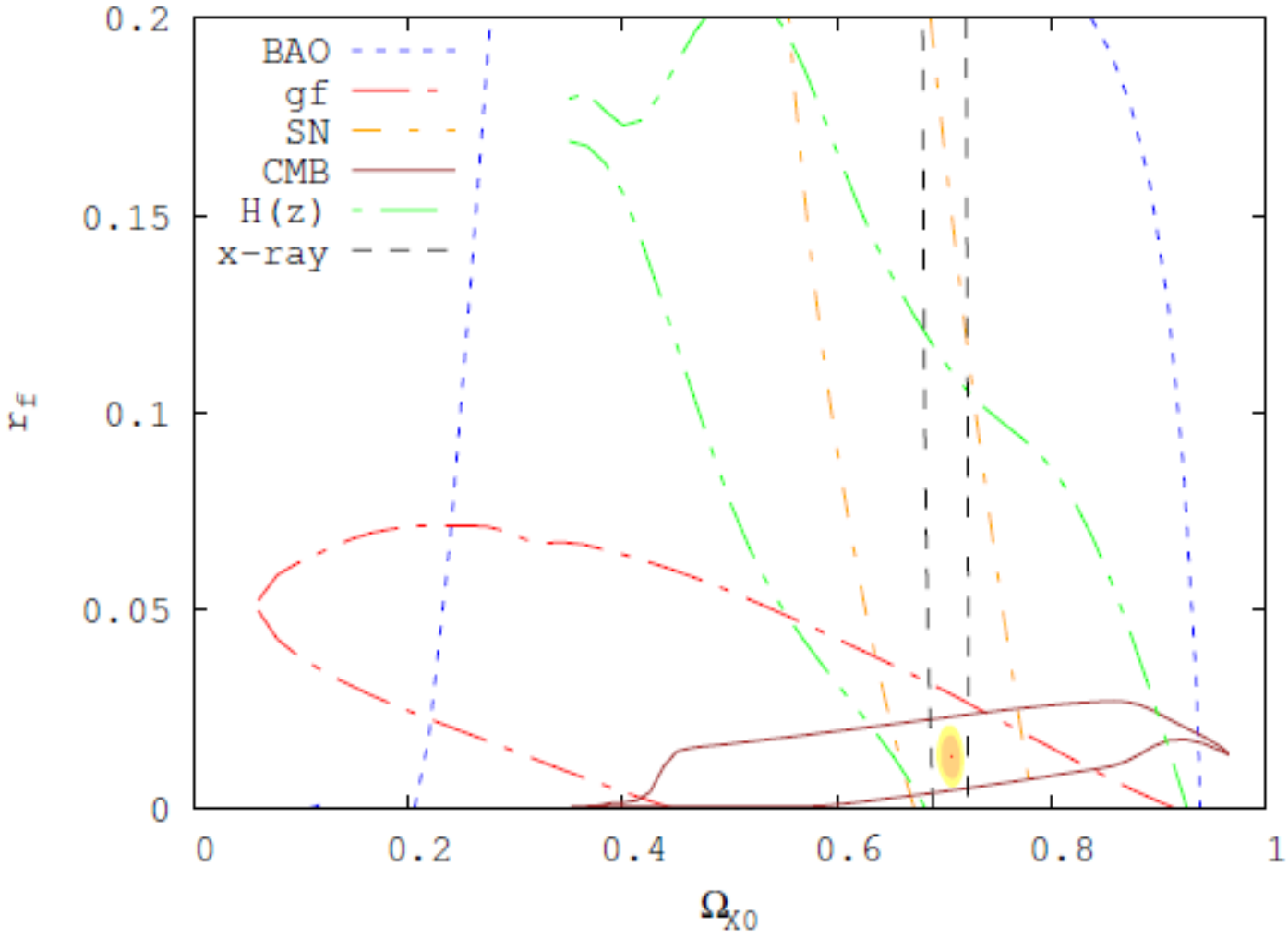




68.3% and 95.4% confidence contours for two pairs of free parameters



The 1sigma probability contours for the pair (Ω_{X0}, c^2)



The 1sigma probaility contours for the pair (Ω_{X0}, r_f)

Best fit values

$$\Omega_{X0} = 0.707 \pm 0.009,\ c^2 = 0.407^{+0.033}_{-0.028},\ r_f = 0.013^{+0.006}_{-0.005},$$

$$\text{and } H_0 = 71.8 \pm 2.9 \text{ km/s/Mpc} \qquad \text{with } \chi^2/dof \approx 0.96$$

Comparison with the LCDM model

Model	χ^2_{sn}	χ^2_{cmb}	χ^2_{bao}	χ^2_{x-rays}	χ^2_H	χ^2_{gf}	χ^2_{total}	$\chi^2_{\text{total}}/dof$
Holographic	543.70	0.01	1.20	41.79	9.57	1.06	597.34	0.96
ΛCDM	542.87	0.05	1.13	41.59	8.73	0.43	594.80	0.96

Table I. χ^2 values of the best fit holographic model ($\Omega_X = 0.707 \pm 0.009$, $c^2 = 0.407^{+0.033}_{-0.028}$, $r_f = 0.013^{+0.006}_{-0.005}$, and $H_0 = 71.8 \pm 2.9\,\text{km/s/Mpc}$), and the best fit ΛCDM model ($\Omega_{M0} = 0.266 \pm 0.006$, and $H_0 = 71.8 \pm 1.9$ km/s/Mpc).

Discussion & Conclusions

(i) The interacting holographic dark energy at the Ricci scale model shows compatibility with the observational data; it looks a promising candidate to account for the present accelerated expansion phase and much alleviates the coincidence problem.

(ii) The LCDM model is favored from the statistical stand-point but it cannot solve the aforesaid problem.

(iii) Additional observational and accurate data are required to further constrain this class of models.

THANKS SO MUCH FOR YOUR KIND ATTENTION!!