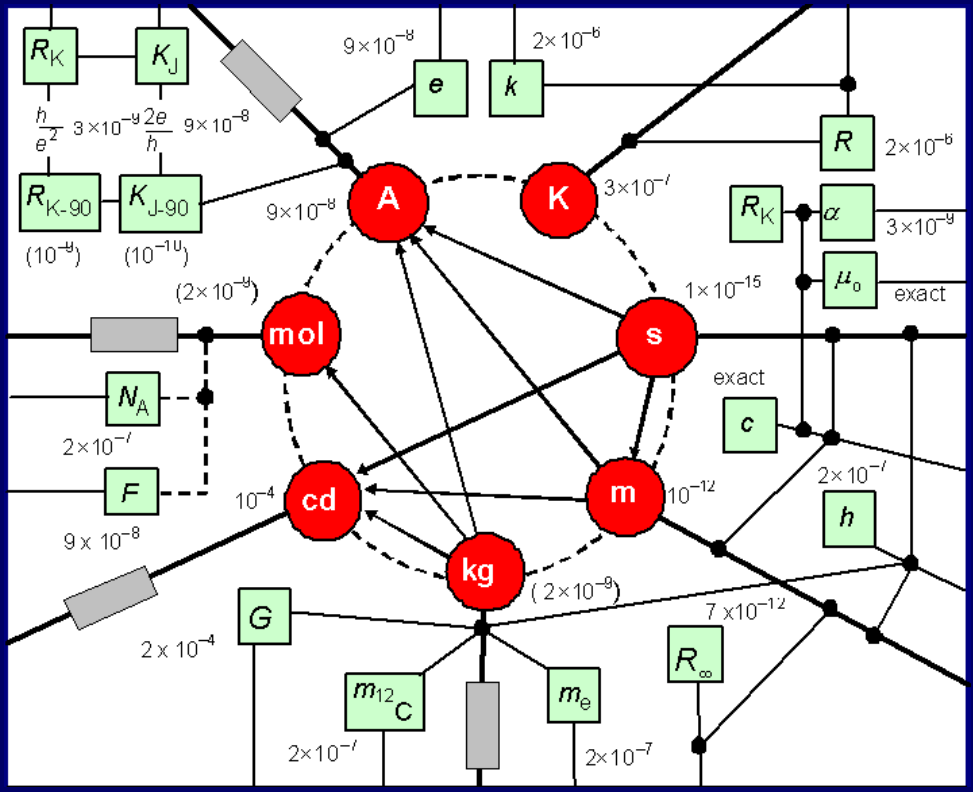
The ongoing quest for variation of the fundamental physical constants

Martin Wendt – Hamburger Sternwarte – C4



SFB Meeting DESY Zeuthen 14.+15.02.2008

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- Short introduction of theory behind variation

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- Outlook

Potential origins of varying constants

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- the dark energy issue requires a fine tuned cosmological constant
- a dynamical scalar field appears more likely
- outstanding consequences in case of observed variation:
- existence of scalar fields, possible reconstruction of the quintessence potential

Where can variation be expected?

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- 4 numbers for the Kobayashi-Maskawa matrix

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- the strong coupling constant
- the cosmological constant

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Of the selected 26 constants, 22 are related to the yet to be discovered Higgs!
Not very helpful from an astronomer’s point of view...

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- $\mu = \frac{m_p}{m_e} =$ ratio of strong to weak forces!

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- R is not well defined and model dependent

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- in general the strong-coupling is running faster than α and $\Delta\mu$ is expected to be larger than $\Delta\alpha$

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- radioactive decay (^{187}Re$\rightarrow^{187}$Os) of meteorites: $\Delta\alpha \leq 10^{-6}$

BUT

A constant variation of constants?

Linearity is a mere assumption and may not apply, neither temporally nor spatial.

Measurements on cosmological scales

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- BBN ($z = 10^9$): $\Delta\alpha \leq 10^{-2}$

Constraints via primordial nucleosynthesis

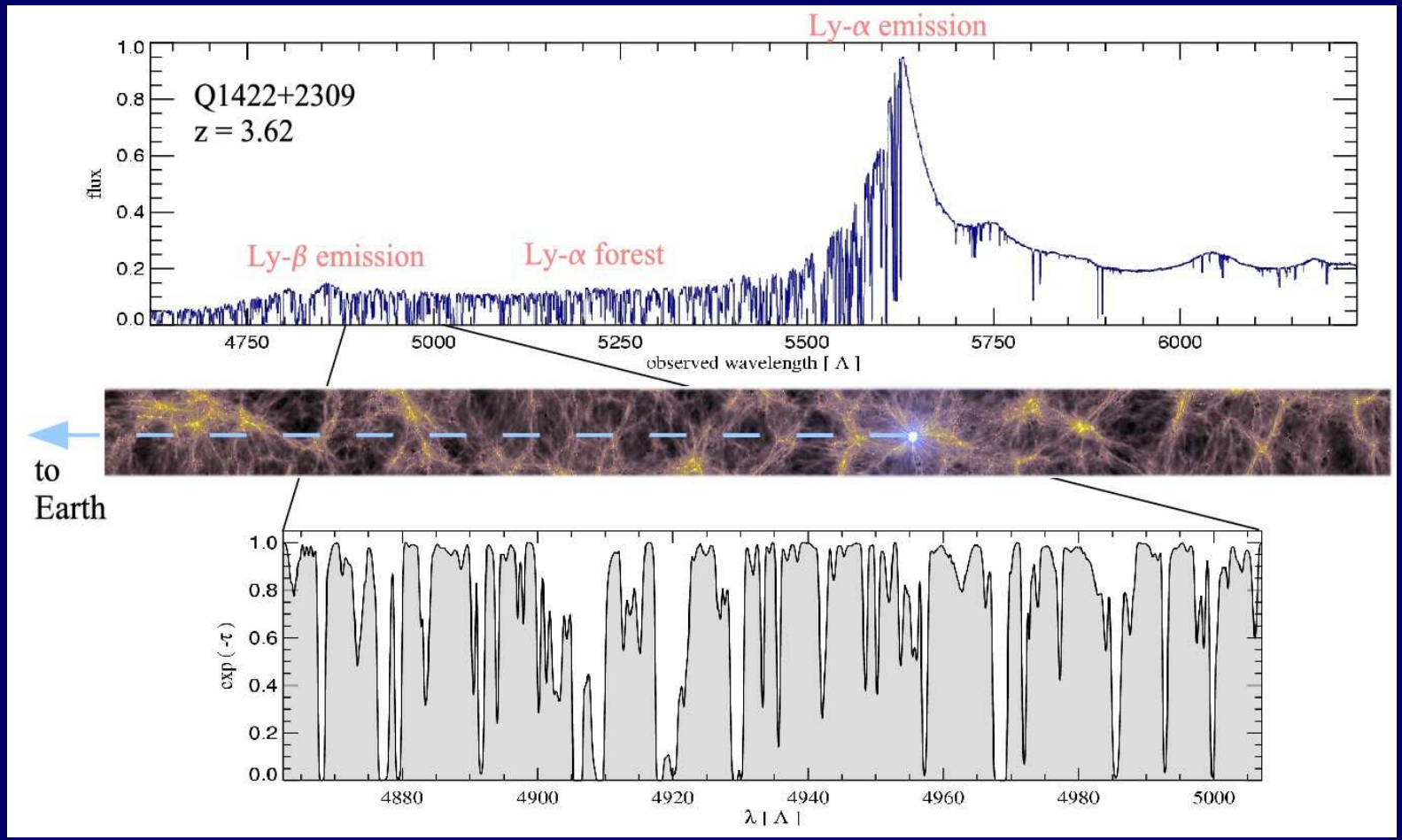
$\partial \ln Y_a / \partial \ln X_i$	D	^{3}He	^{4}He	^{6}Li	^{7}Li
G_N	0.94	0.33	0.36	1.4	-0.72
α	2.3	0.79	0.00	4.6	-8.1
τ_n	0.41	0.15	0.73	1.4	0.43
m_e	-0.16	-0.02	-0.71	-1.1	-0.82
Q_N	0.83	0.31	1.55	2.9	1.00
m_N	3.5	0.11	-0.07	2.0	-12
$B_{\rm D}$	-2.8	-2.1	0.68	-6.8	8.8
$B_{\rm T}$	-0.22	-1.4	0	-0.20	-2.5
$B_{\rm 3He}$	-2.1	3.0	0	-3.1	-9.5
$B_{\rm 4He}$	-0.01	-0.57	0	-59	-57
$B_{\rm 6Li}$	0	0	0	69	0
$B_{\rm 7Li}$	0	0	0	0	-6.9
$B_{\rm 7Be}$	0	0	0	0	81

(Thomas Dent *et al.* 2008)

Measurements in QSO absorption systems

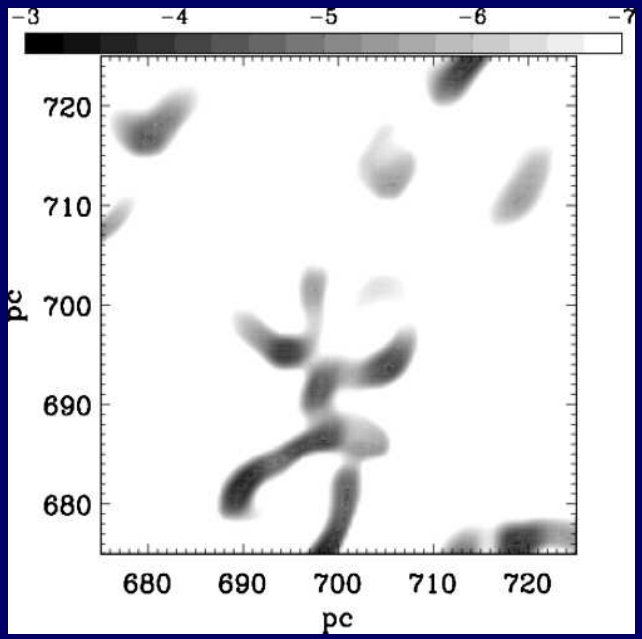
- measurements at different high redshifts
- high spatial and temporal coverage

Quasar absorption line spectroscopy



(Springel et. al 2006)

Absorption systems, i.e., H_2



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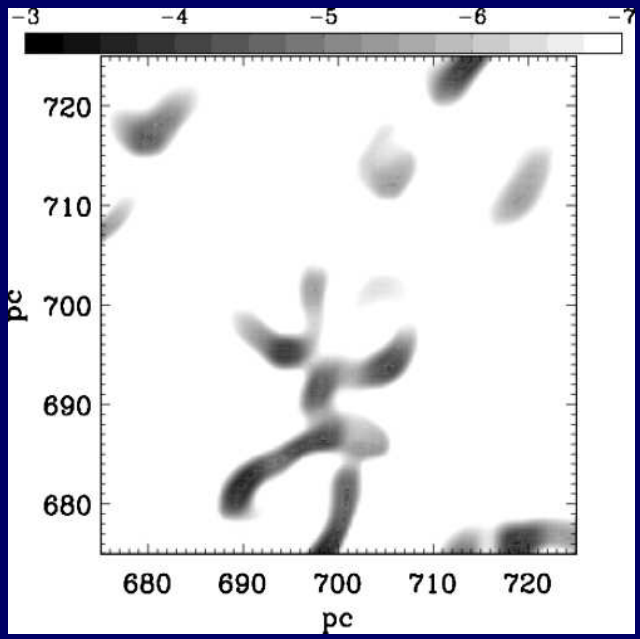

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- observable only in dense systems

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- for $z_{\rm abs} \geq 2.5$ redshifted into Ly forest

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molecular hydrogen H_2

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(Thompson 1975)

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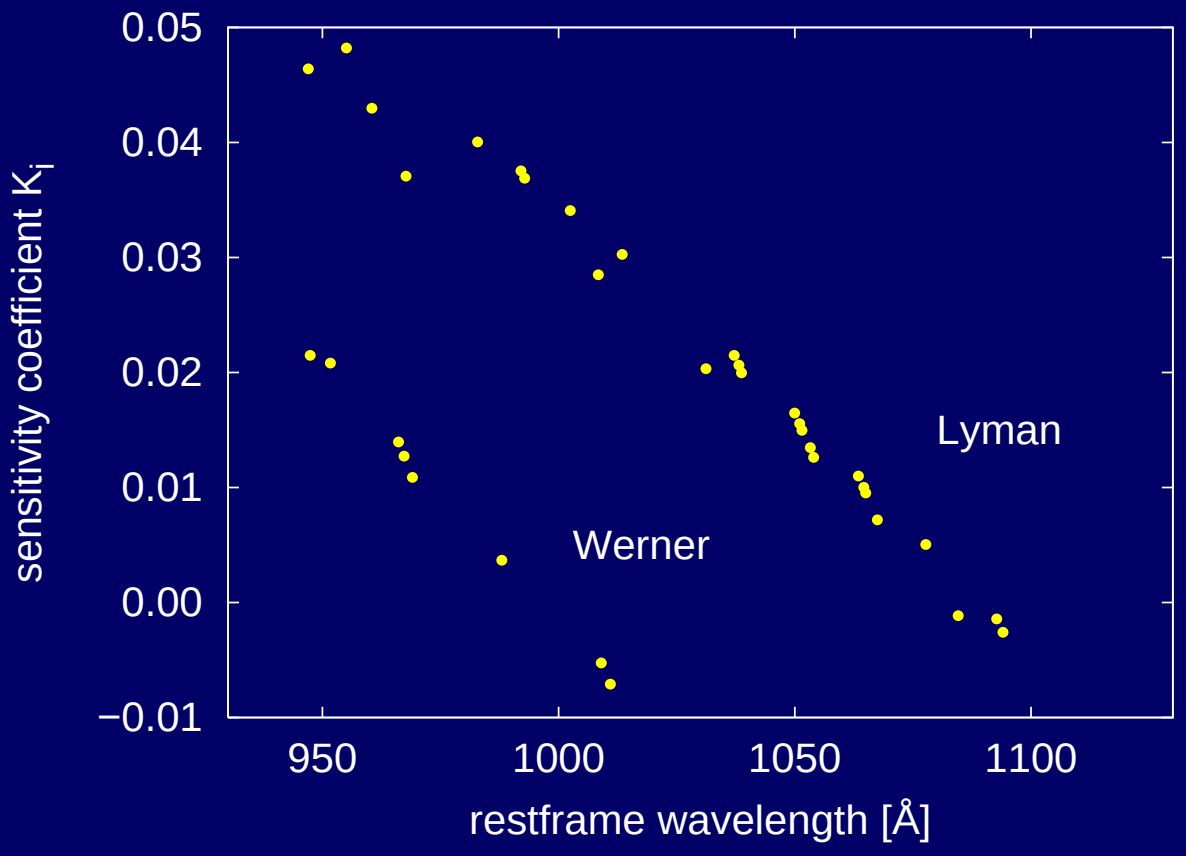

(Reinhold *et al.* 2006)

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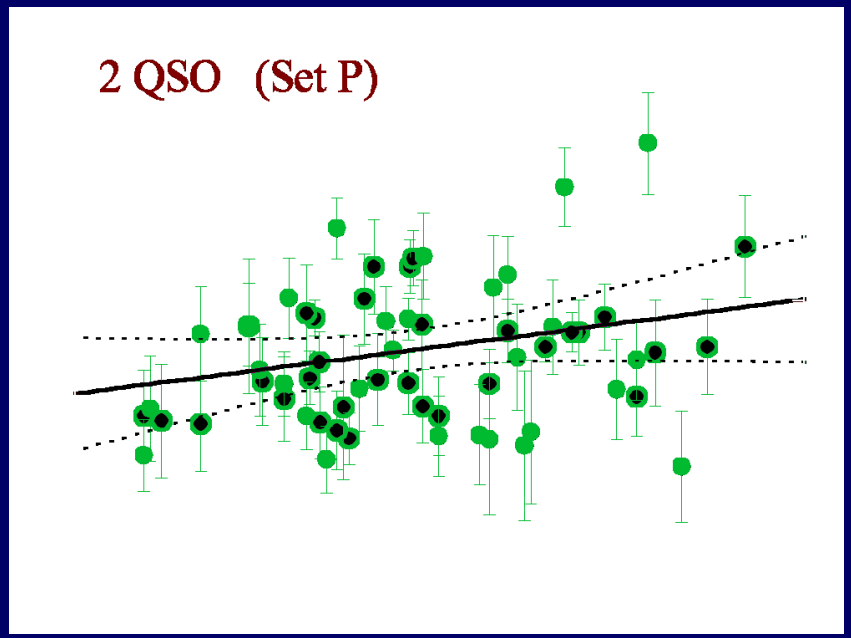

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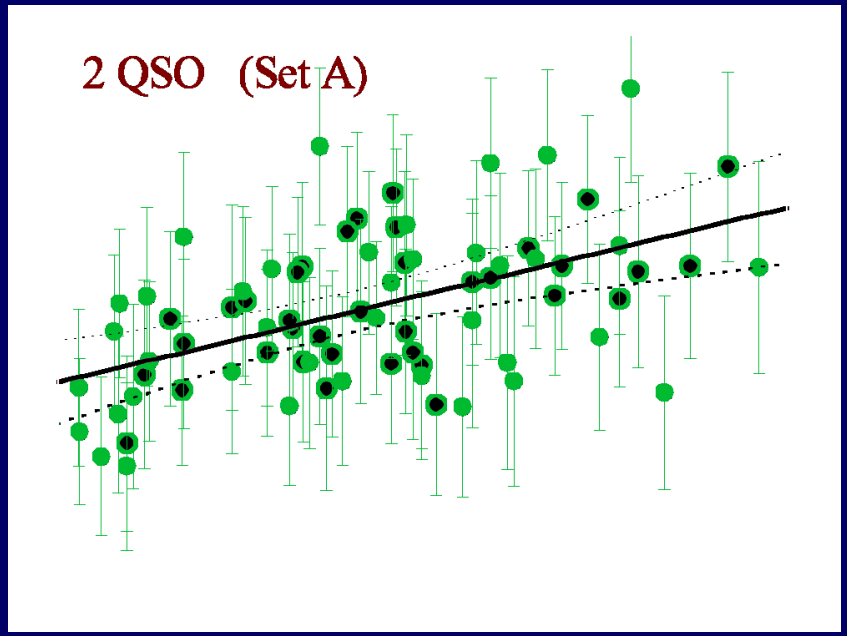

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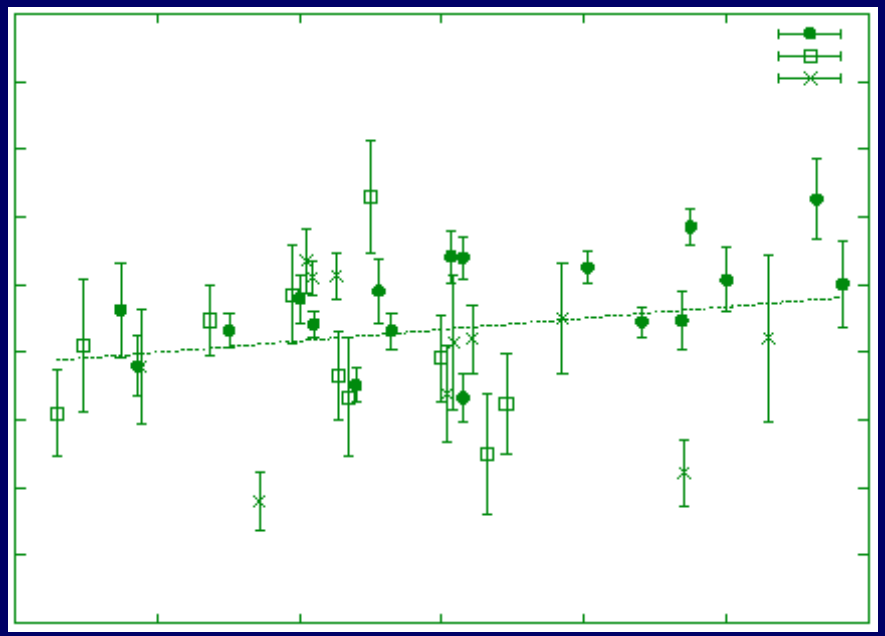

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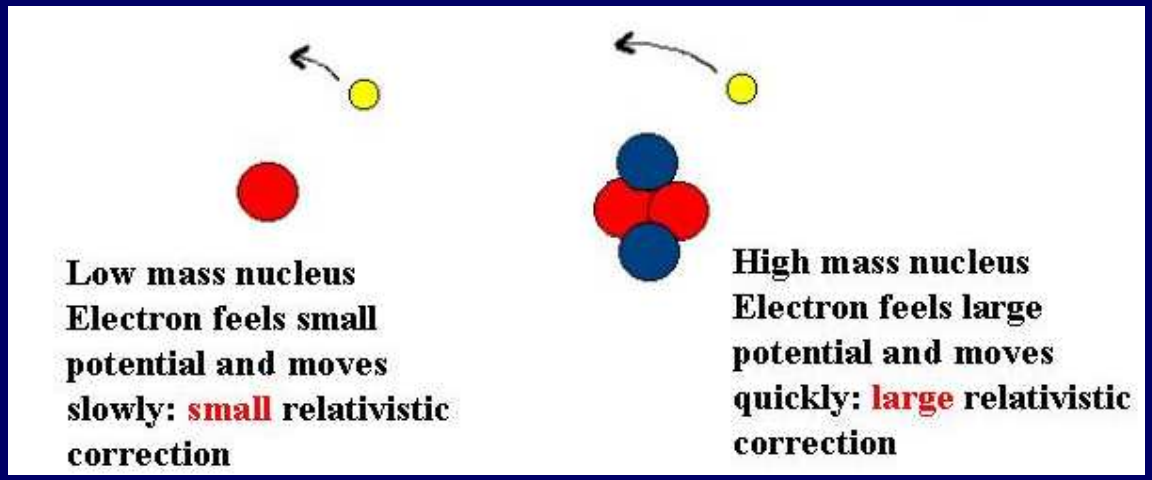
$$\omega_z = \omega_o + q \cdot x$$

with $x_z = (\alpha_z/\alpha)^2 - 1$



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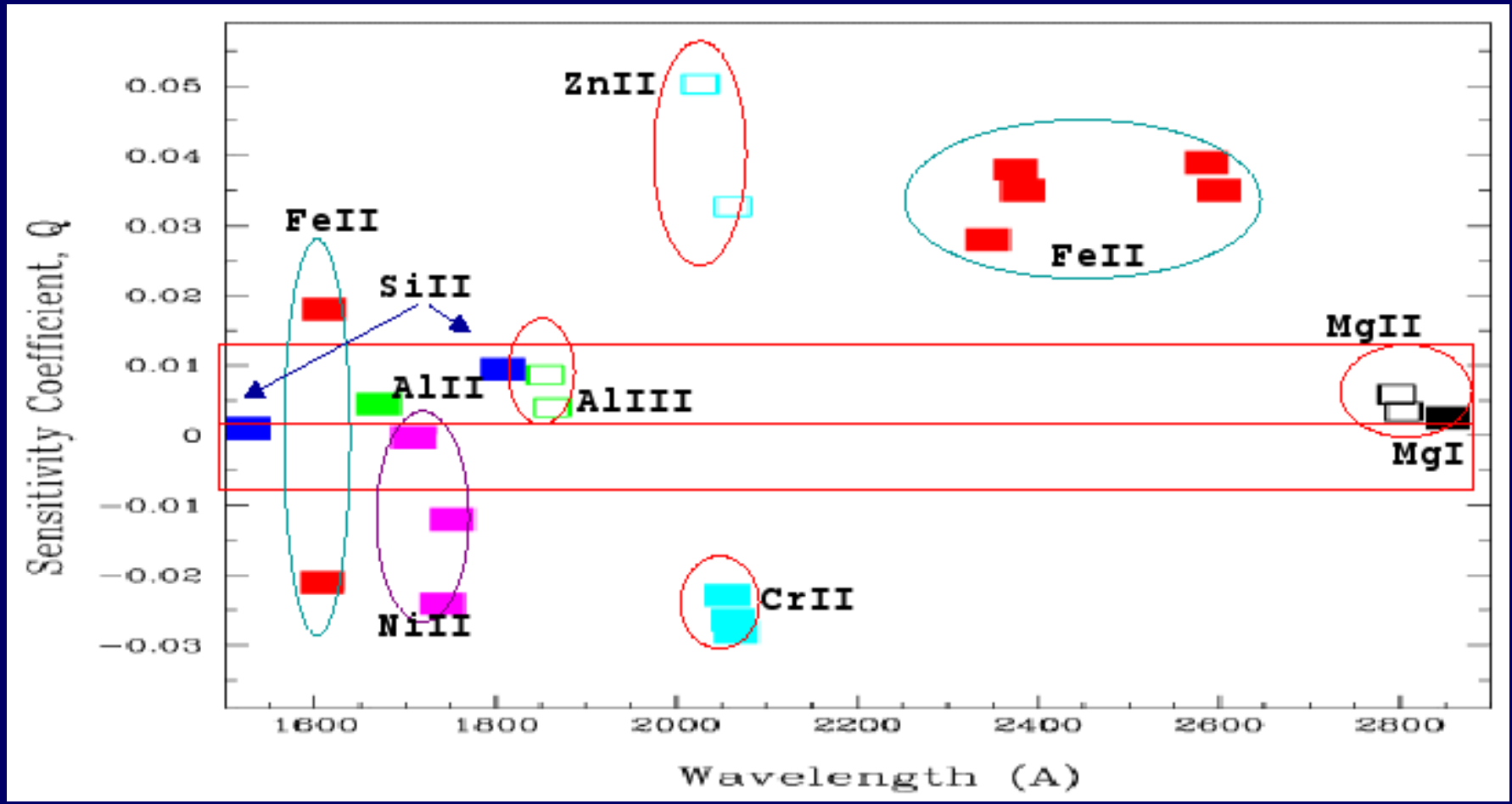
Sensitivity coefficient $Q = q/\omega_z$ (Dzuba 1999)



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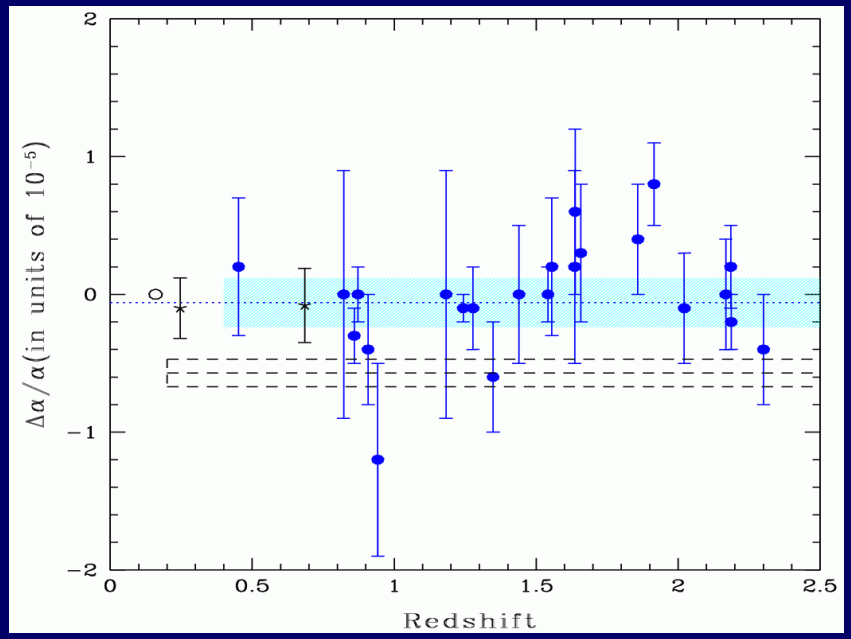

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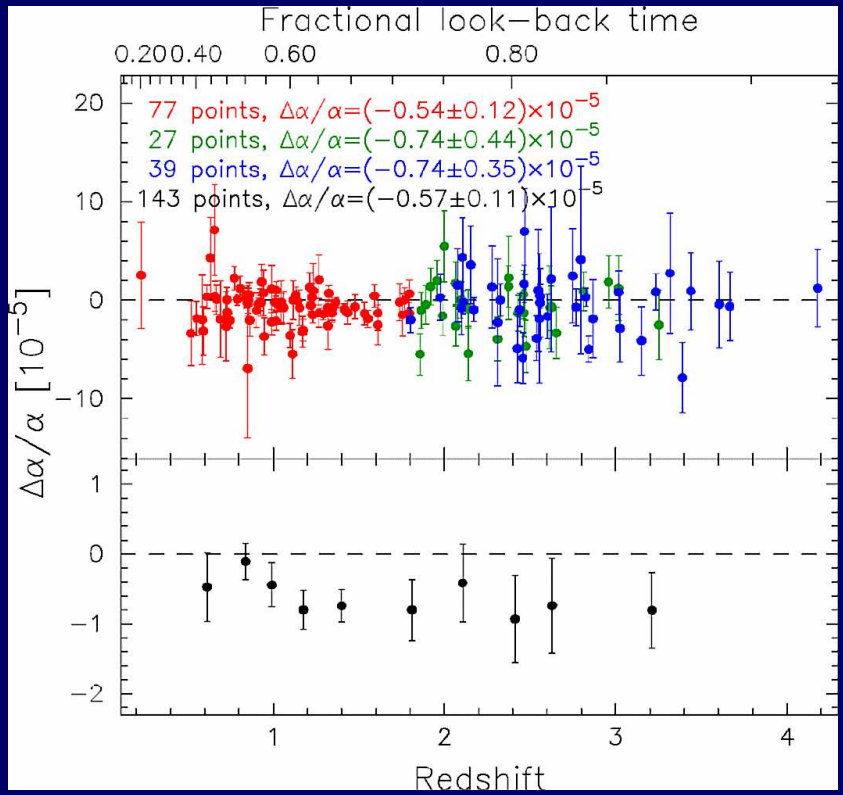

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no final results – research continues (luckyly)

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- a better understanding of the physics involved

More data

please