Variability of the proton-to-electron mass ratio on cosmological scales

Quasar absorption line spectroscopy

Martin Wendt – Hamburger Sternwarte

Osservatorio Astronomico di Trieste, November 28th

Overview

- Short introduction of theory behind variation
- How is variation reflected in observations?
- Molecular Hydrogen H_2
- Methods involved
- Analysis
- Summary and Outlook

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- another byproduct: scalar field as possible source for acceleration

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- variation of the gravitational constant G_N.
  Recent paper last week:
  $\dot{G}_N/G_N \lesssim 10^{-17}\mathrm{yr}^{-1}$.

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- the classical oscillation frequency dependent on the *reduced mass* as $\mu^{-\frac{1}{2}}$.

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- rotational transitions are proportional to μ^{-1}

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- So far observations have borne out this supposition.

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(Varshalovich & Levshakov 1993)

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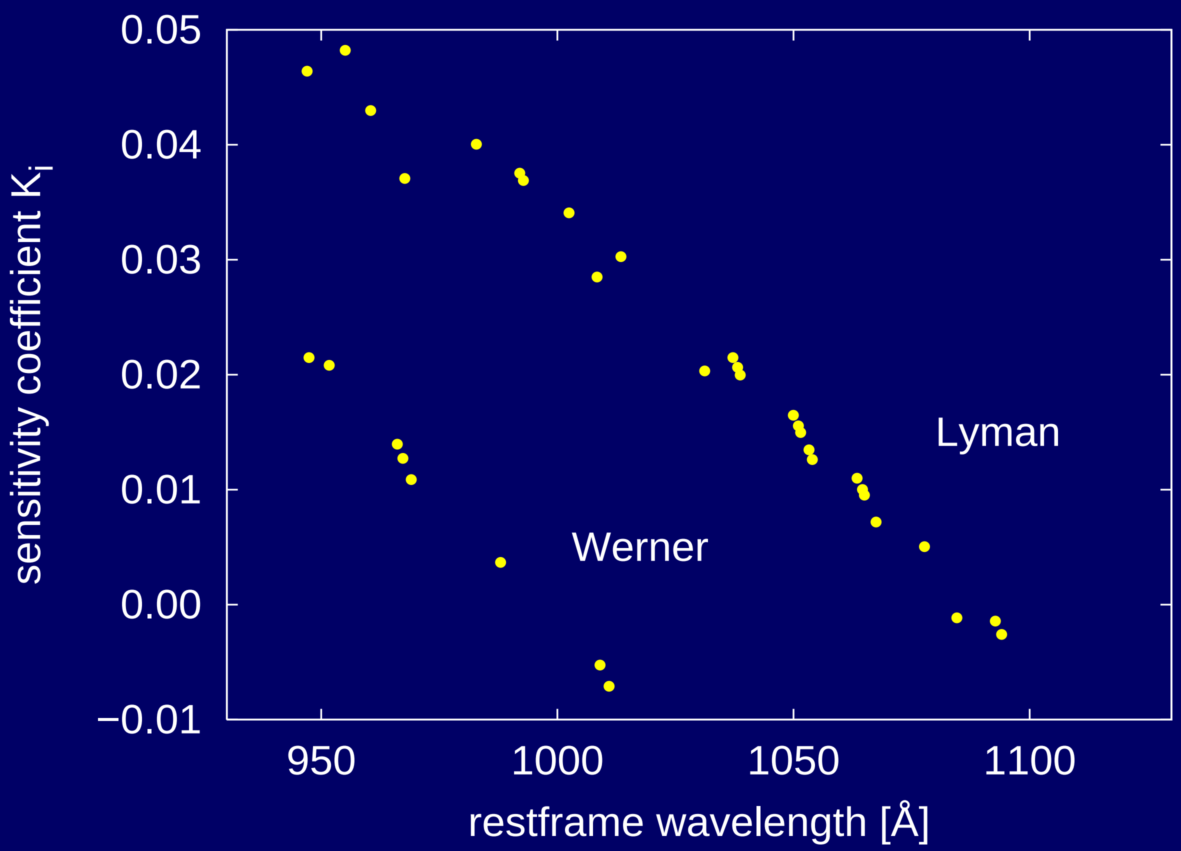

(Reinhold et al. 2006)

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- transitions in UV (restframe) – redshiftet into visual band

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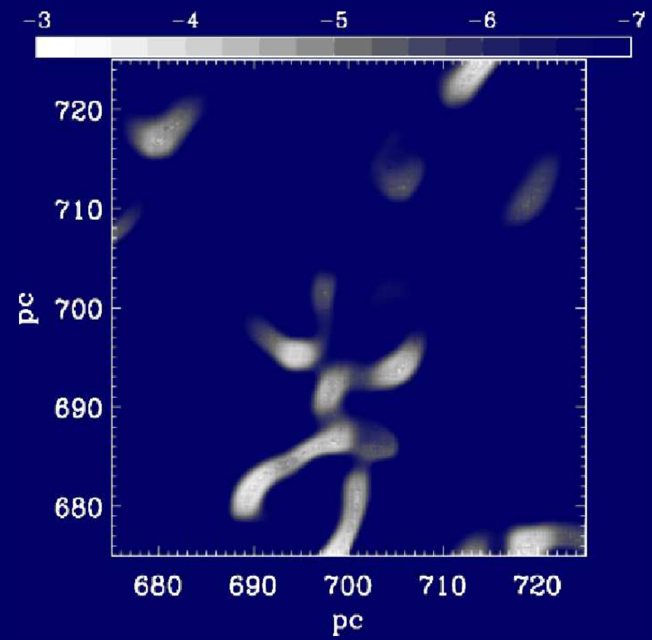

- highly inhomogeneous, clumpy distribution [1]

[1] H.Hirashita, A.Ferrara, K.Wada, P.Richter,P.2003, MNRAS, 341, L18

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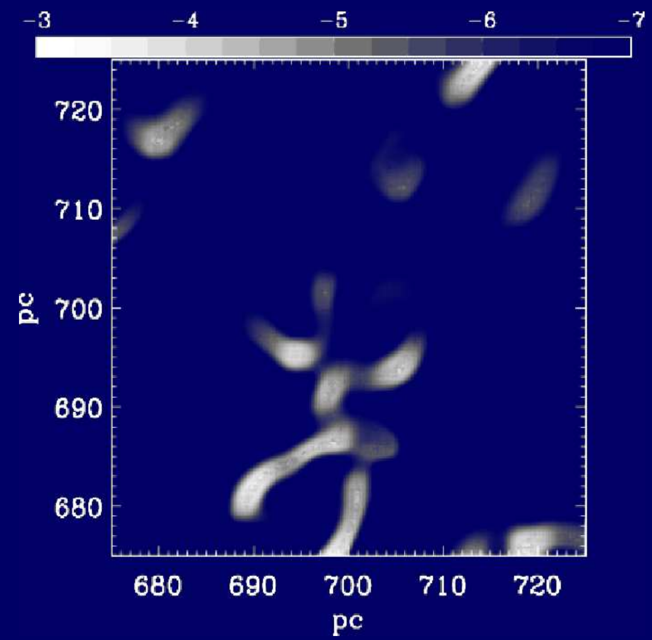

- highly inhomogeneous, clumpy distribution [1]
- observable only in dense systems

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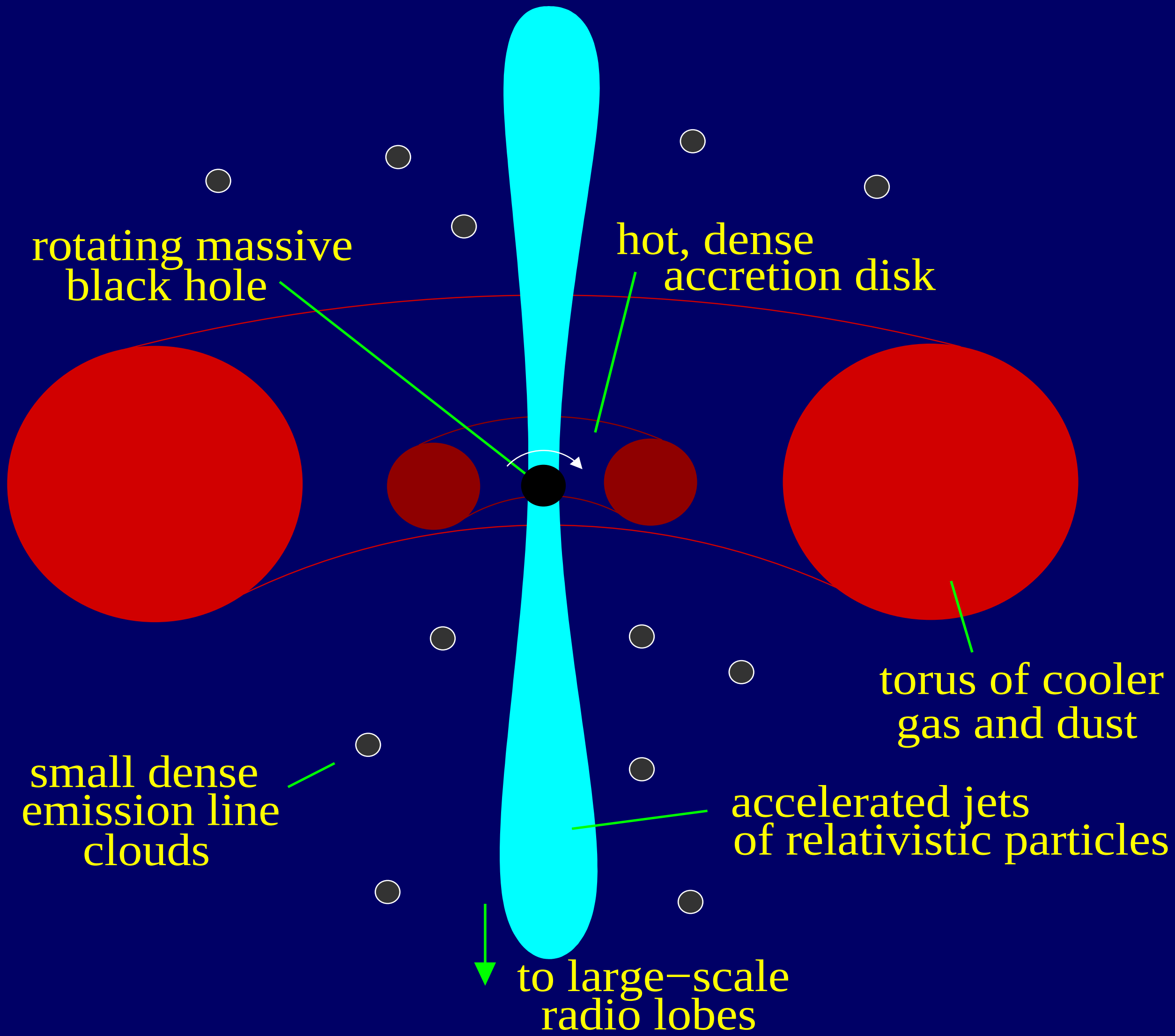

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e.g., the Lyα transition at $\lambda_{\rm rest} = 1215.67$ Å

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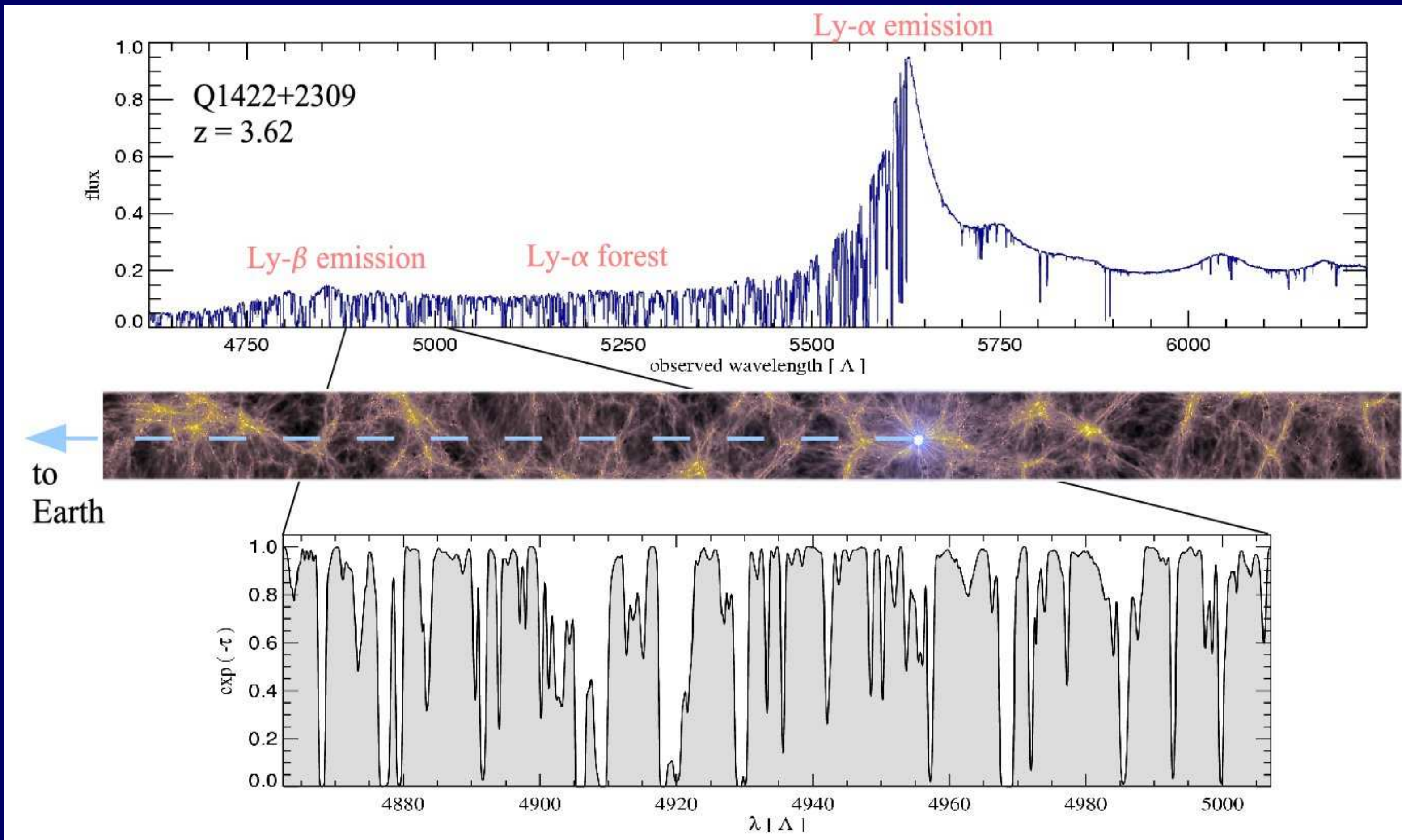
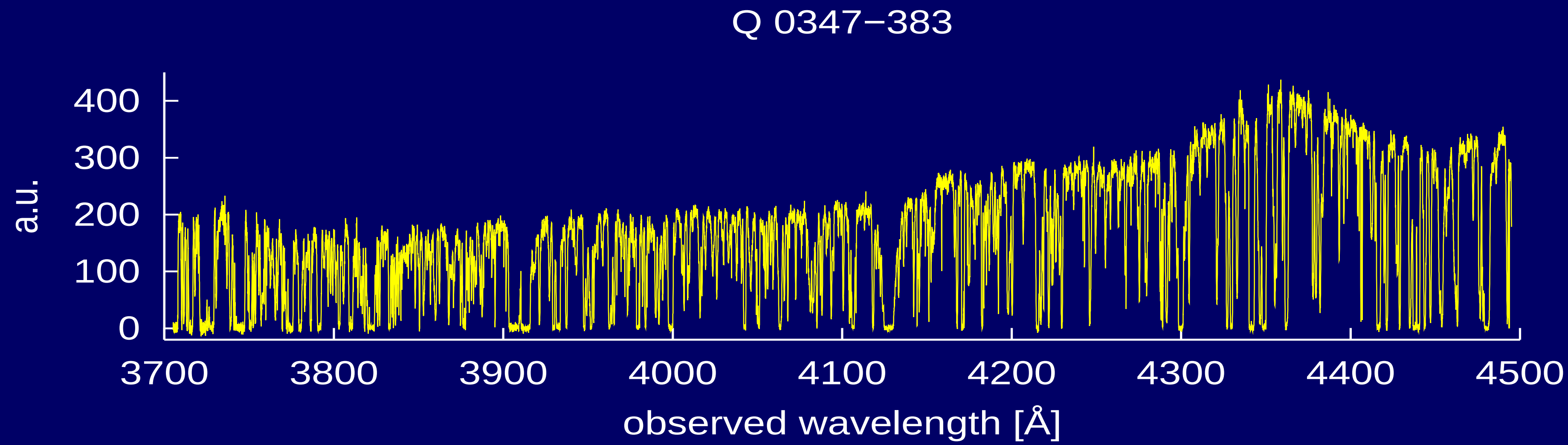


(Springel et. al 2006)

Quasar absorption line spectra - probing the universe



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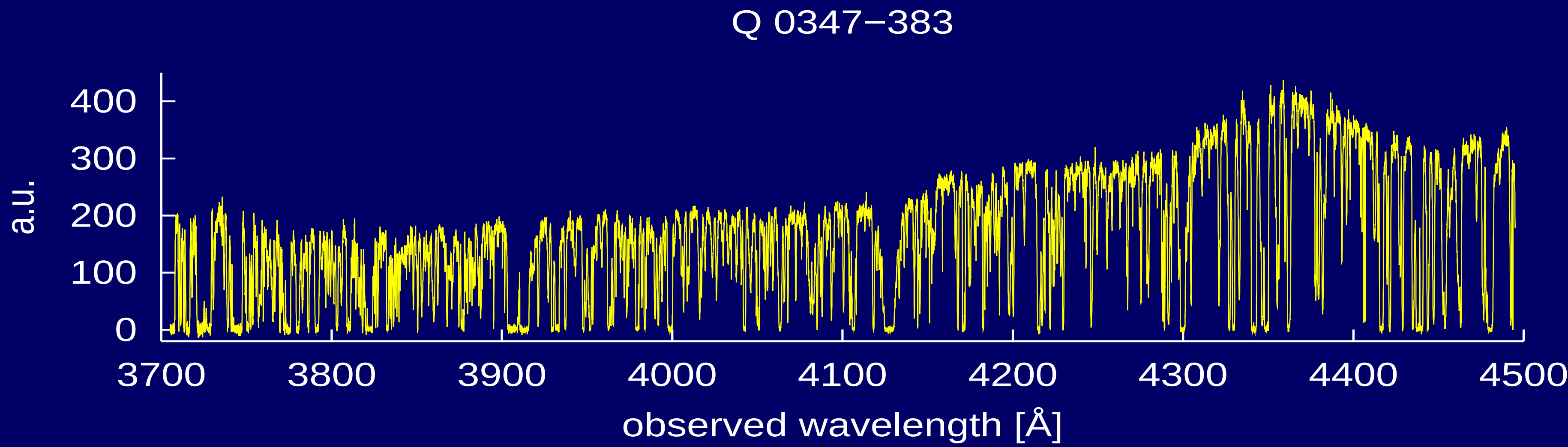

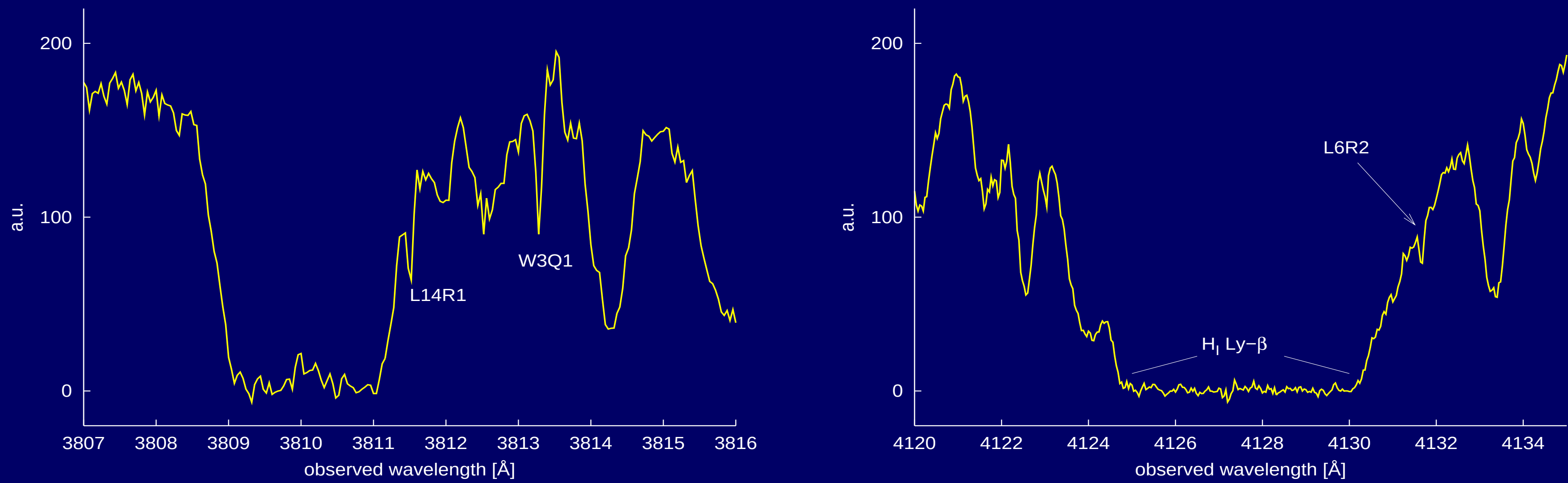

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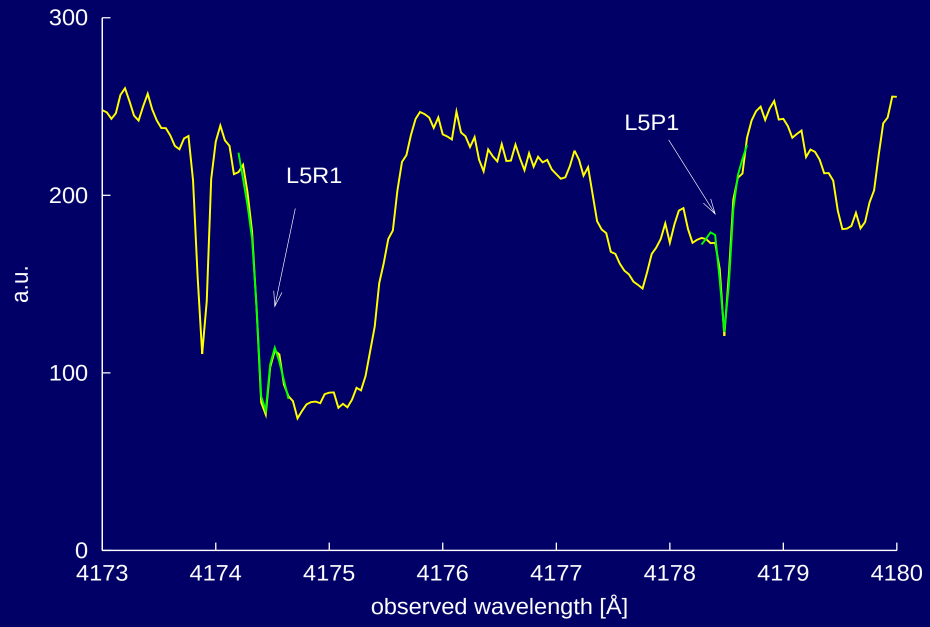

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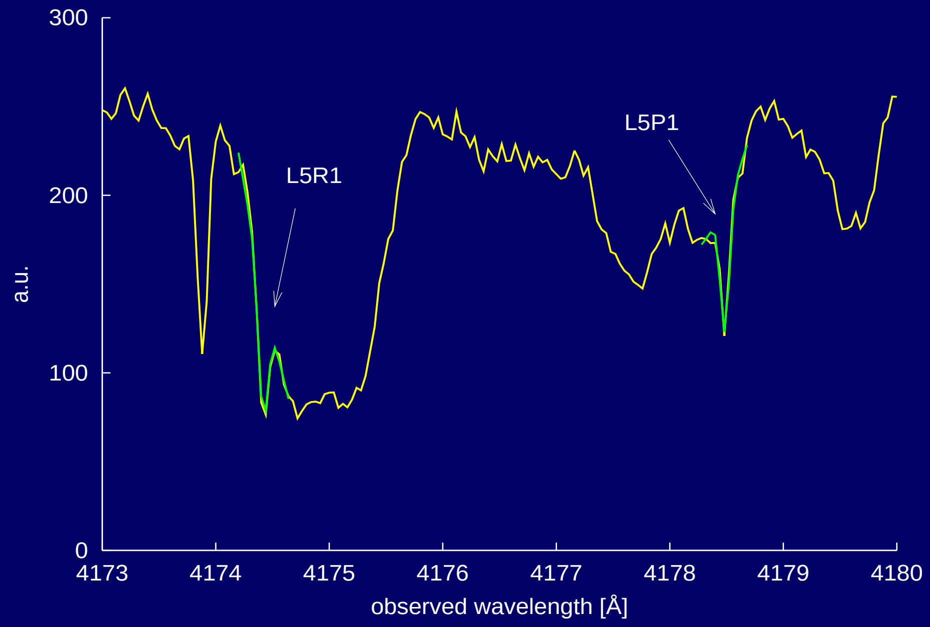

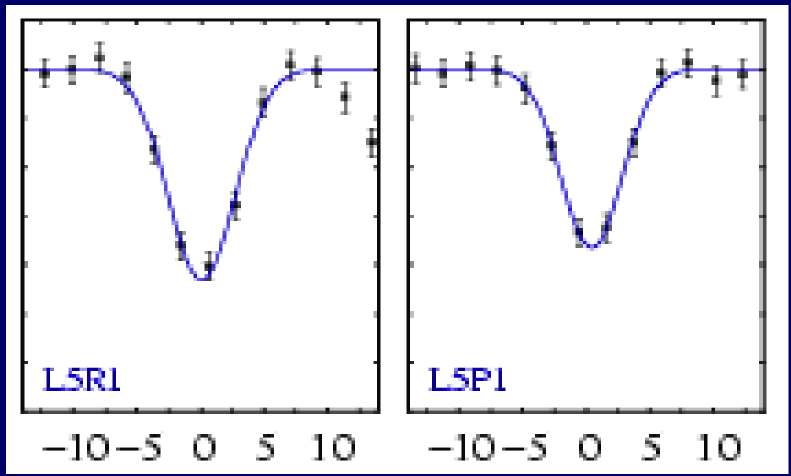

(Ivanchik et al. 2005)

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simulated fits to estimate accuracy

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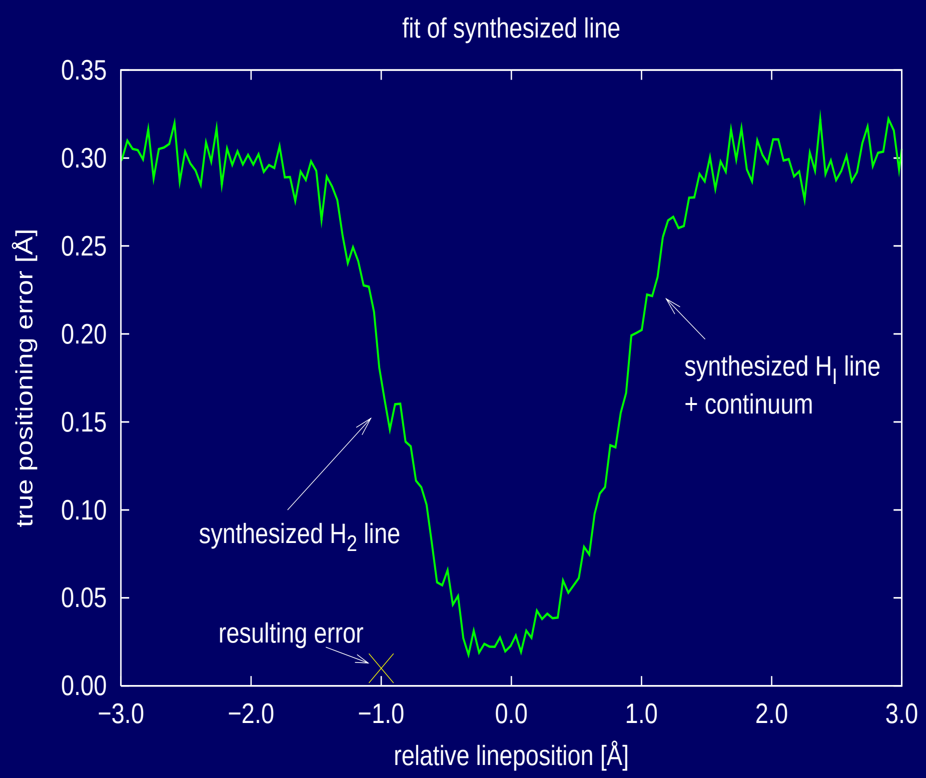

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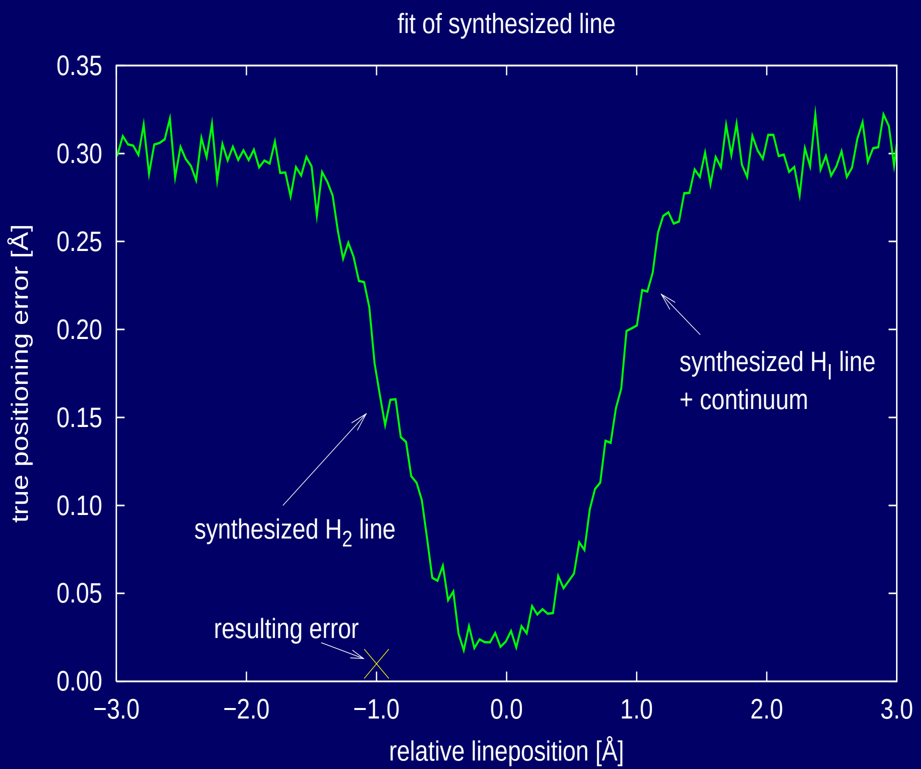

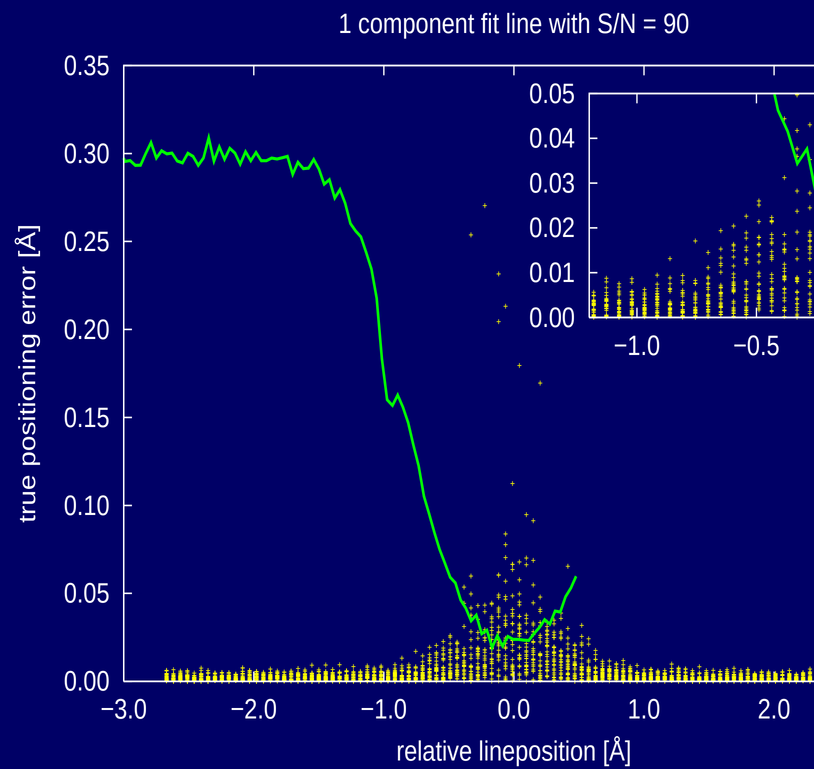

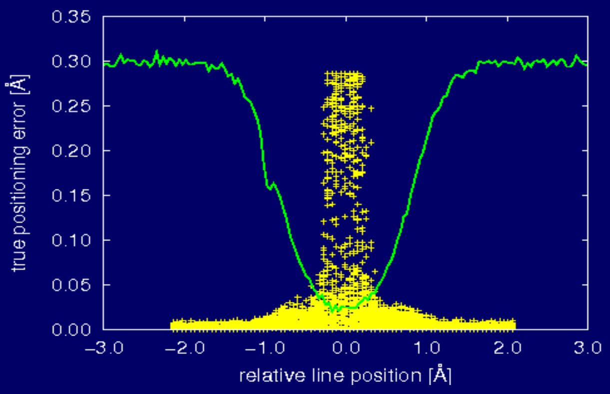
true positioning error [Å]
relative line position [Å]
0.00
0.05
0.10
0.15
0.20
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1.0
2.0
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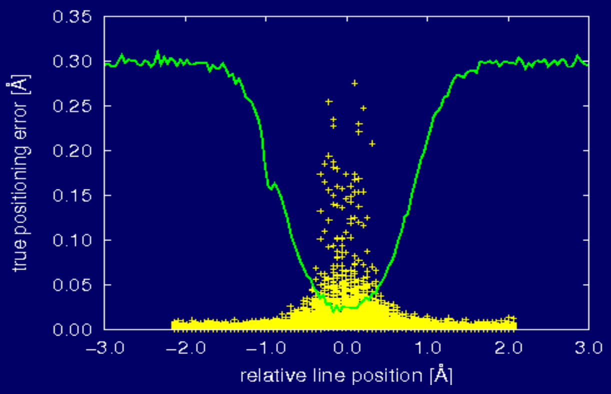
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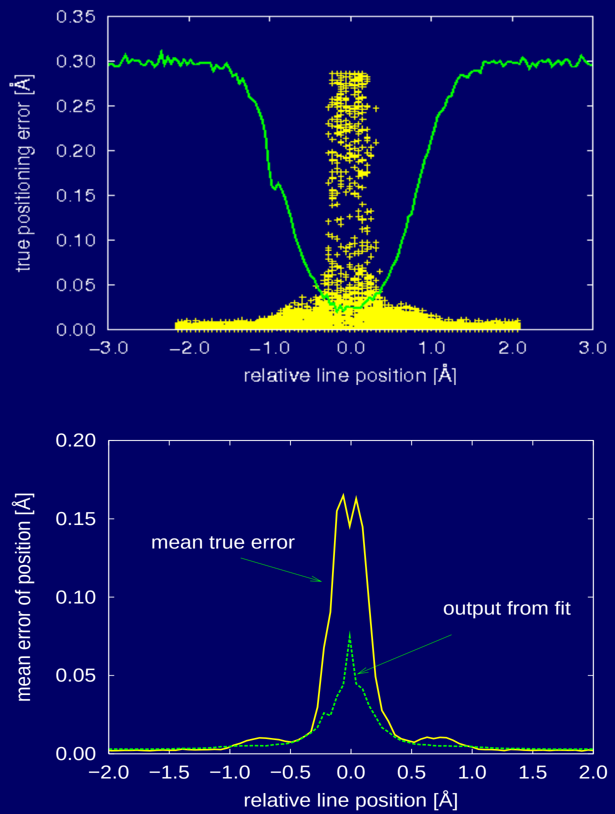
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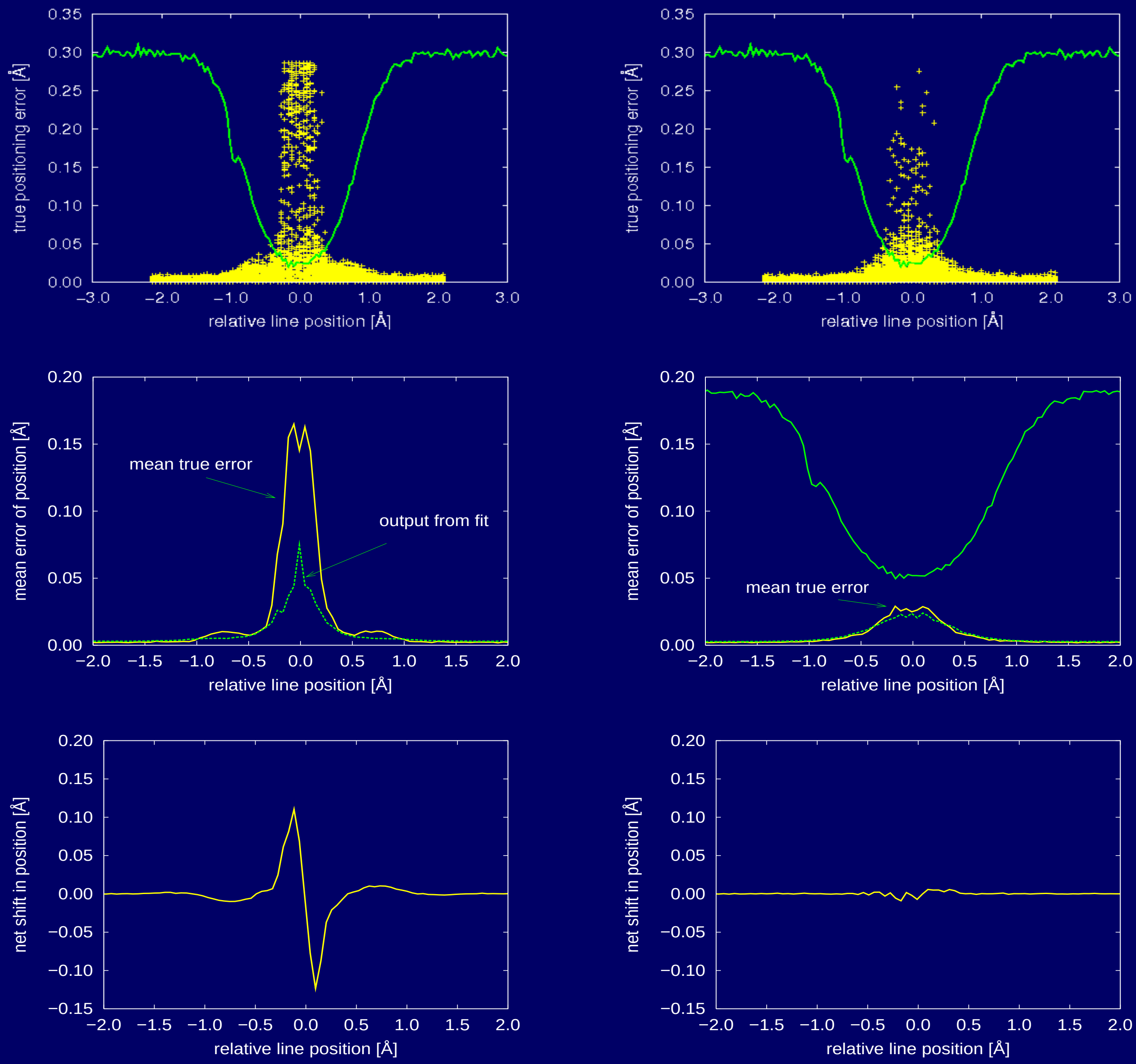
mean error of position [Å]
mean true error
output from fit
mean true error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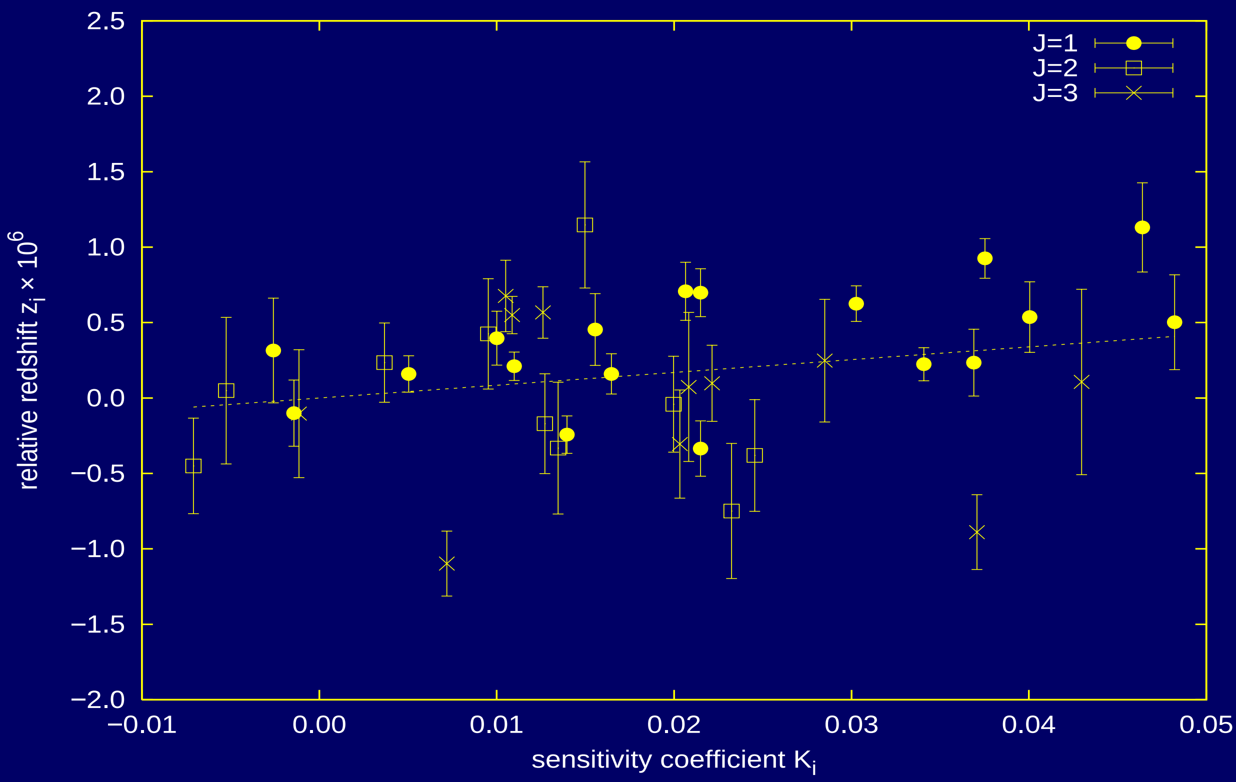

corresponding to $\frac{\Delta\mu}{\mu} = 2.1 \pm 1.4 \times 10^{-5}$

(Reinhold et al. 2006: $\frac{\Delta\mu}{\mu} = 2.0 \pm 0.6 \times 10^{-5}$)

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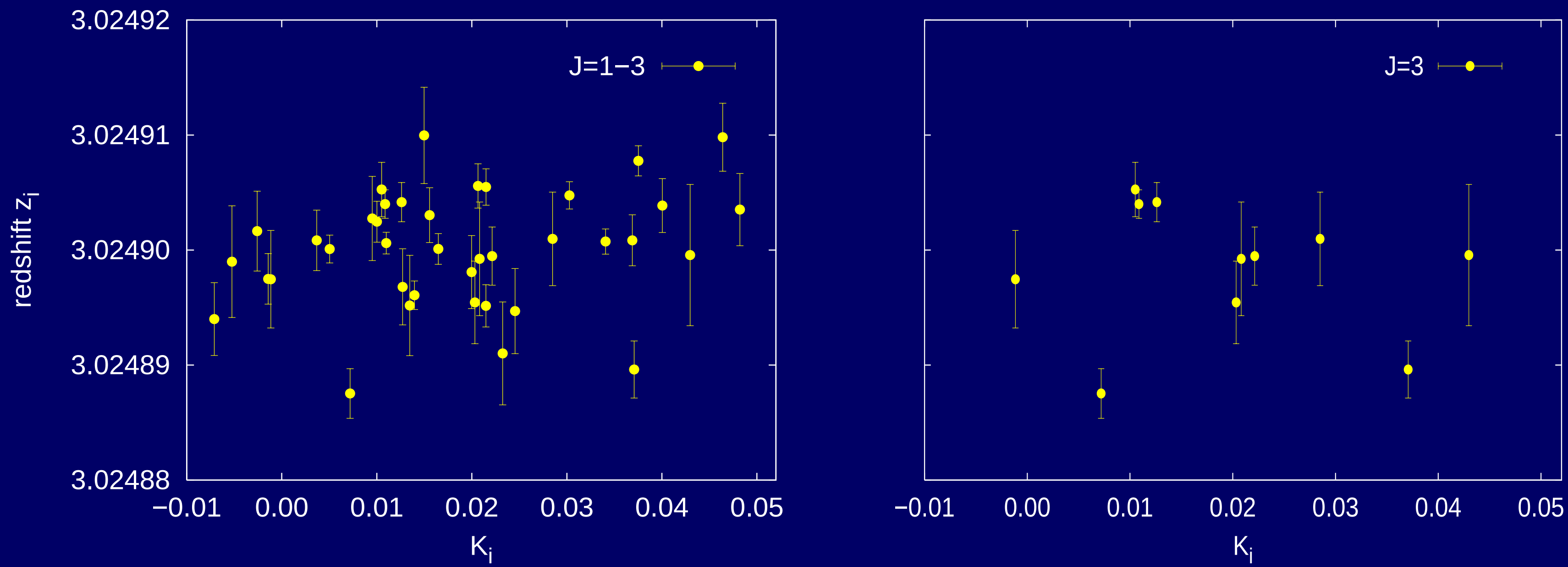

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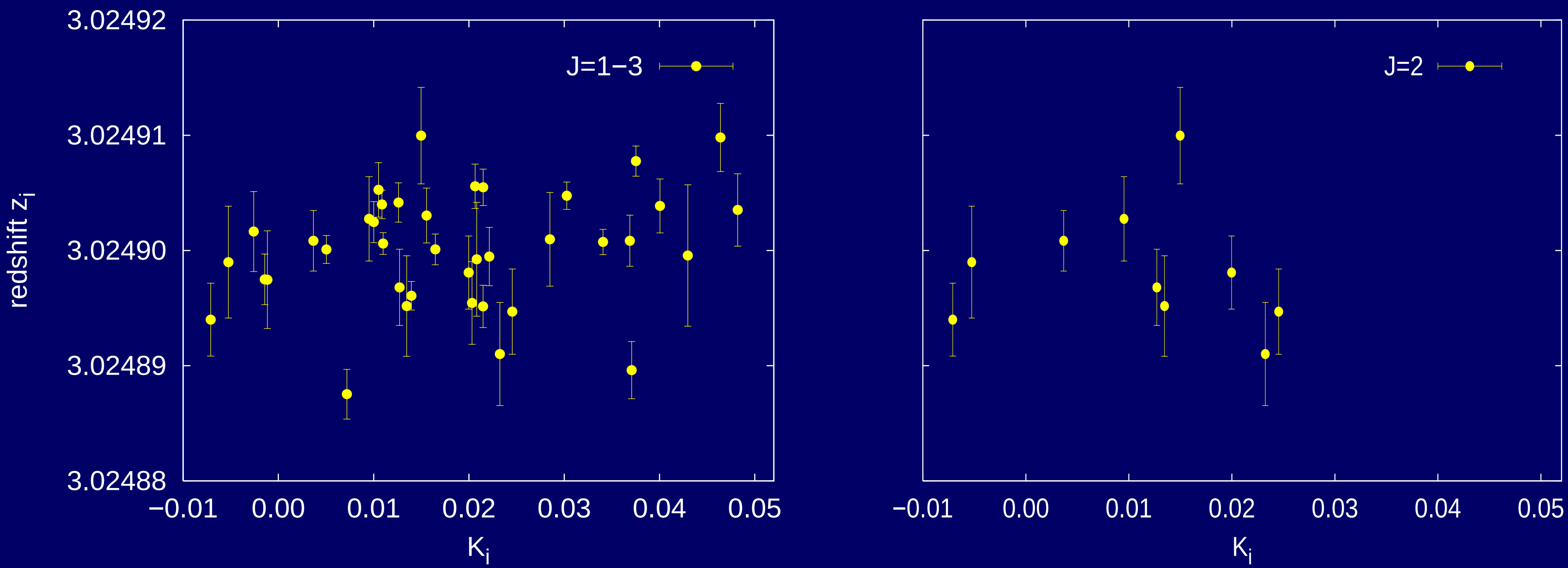

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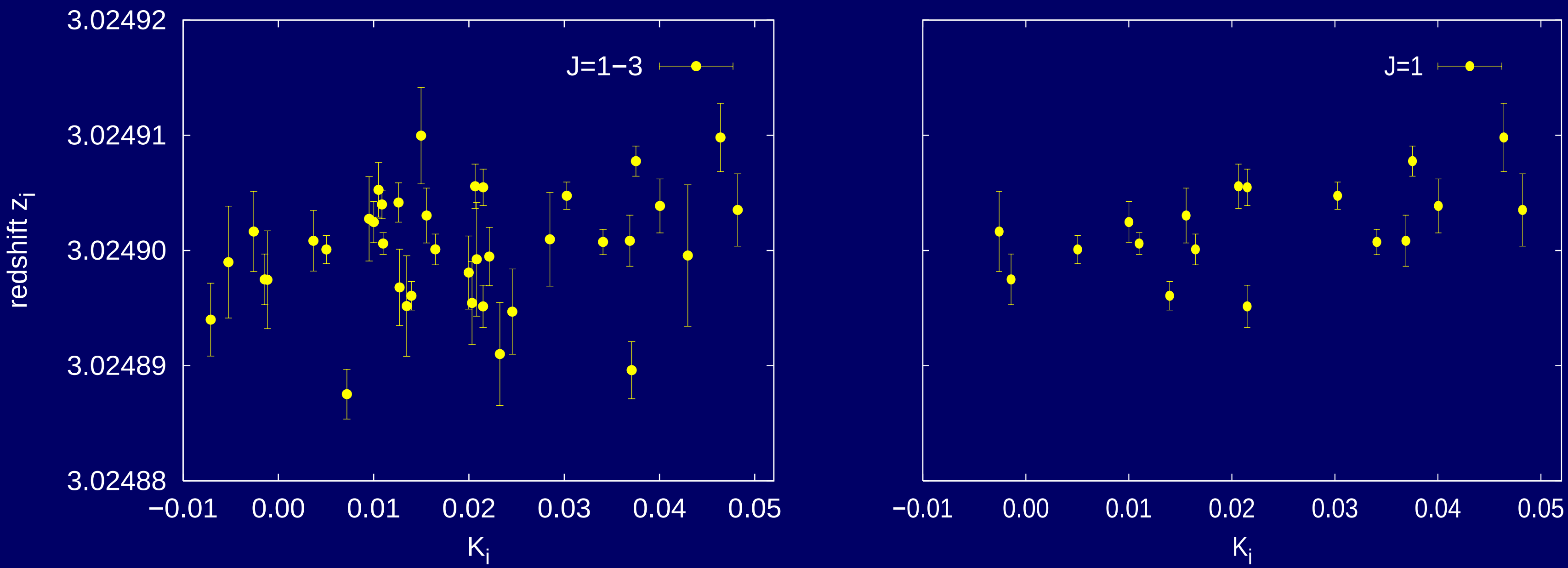

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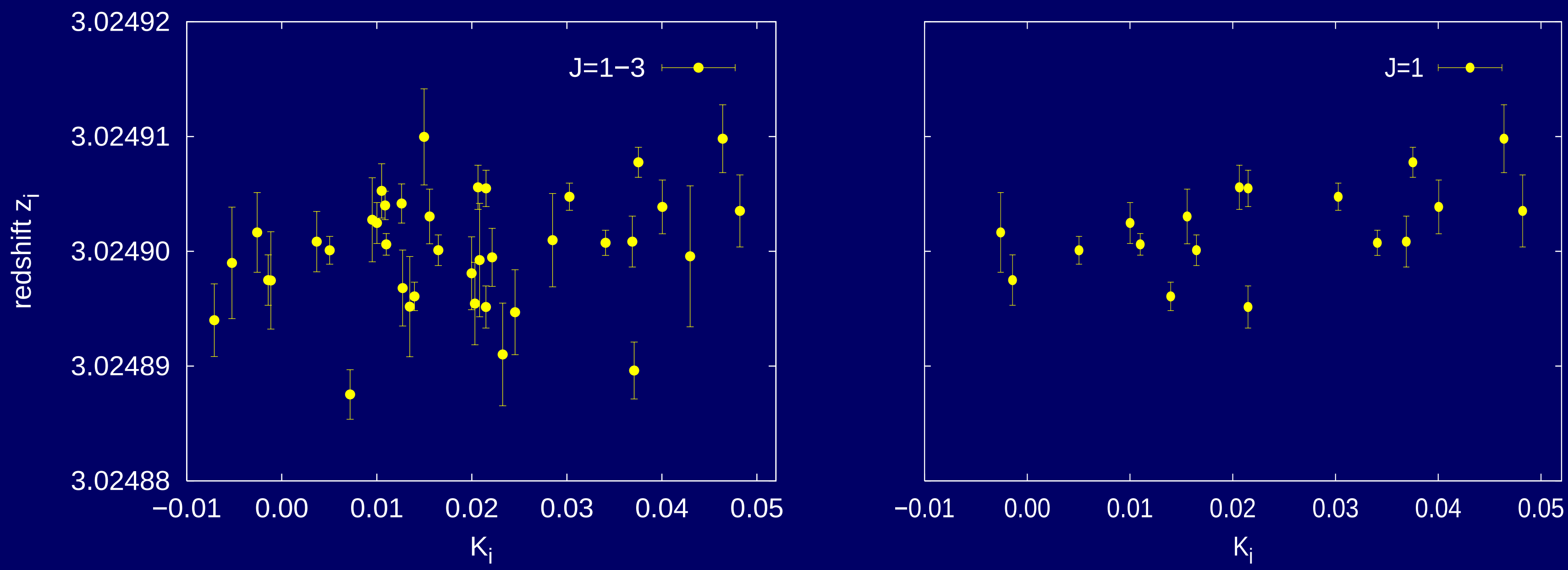
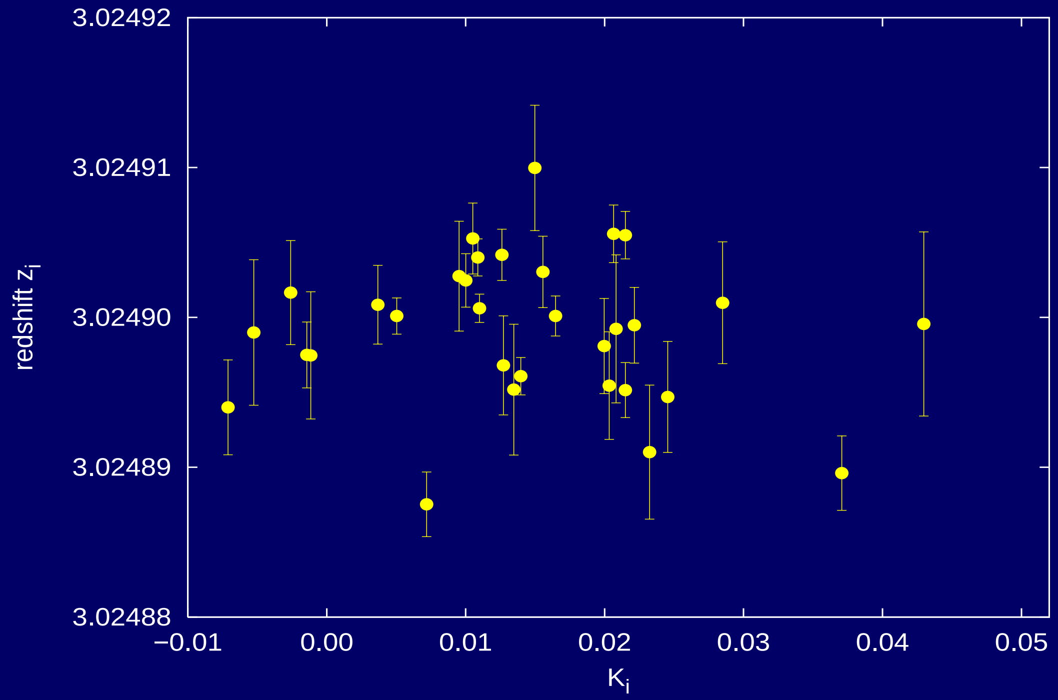


Merely transitions with high vibrational quantum numbers in the first rotational level contribute to a positive result

News or noise?



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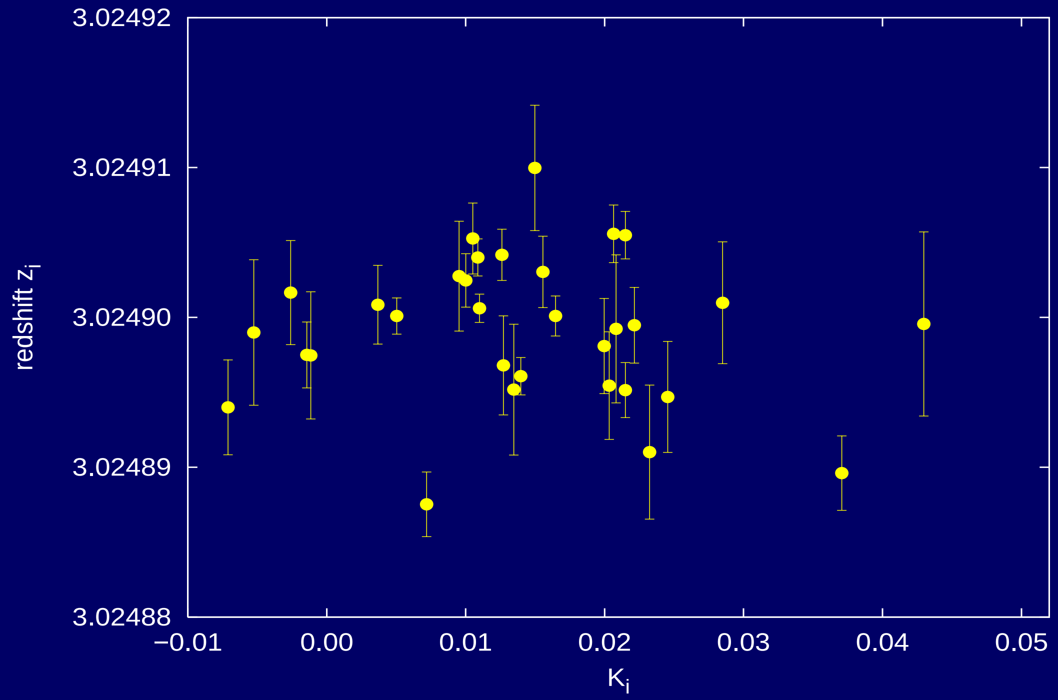

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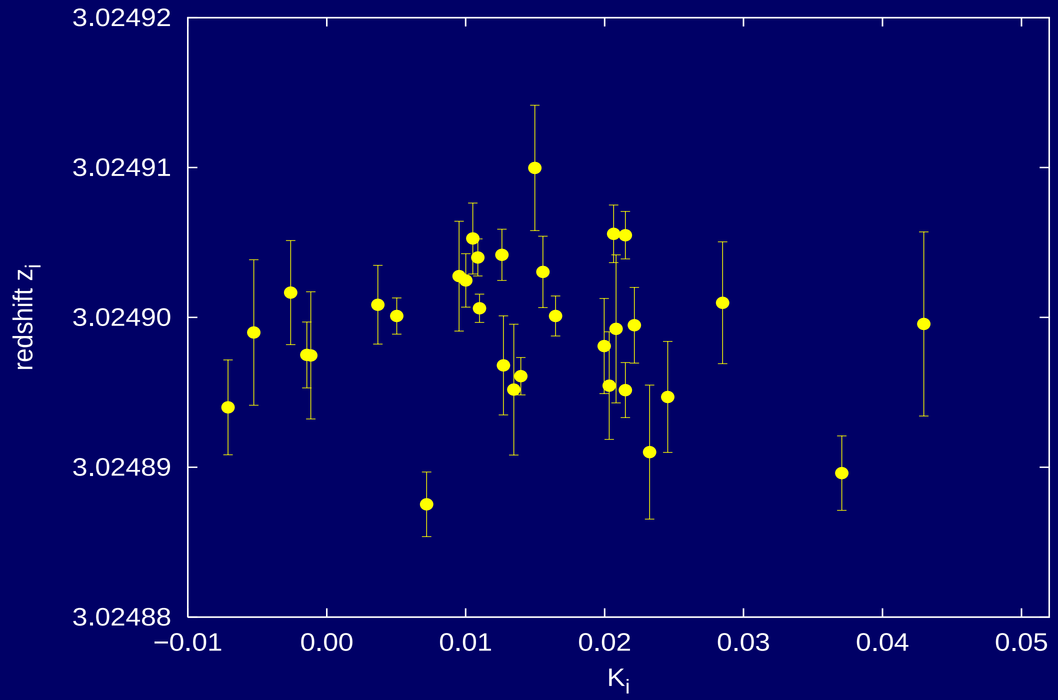

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$|\Delta\mu/\mu| \leq 4.9 \times 10^{-5}$ over the period of $\approx$ 11.5 Gyr

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- further simulations of detectability of variation
- better understanding of the nature of DLAs

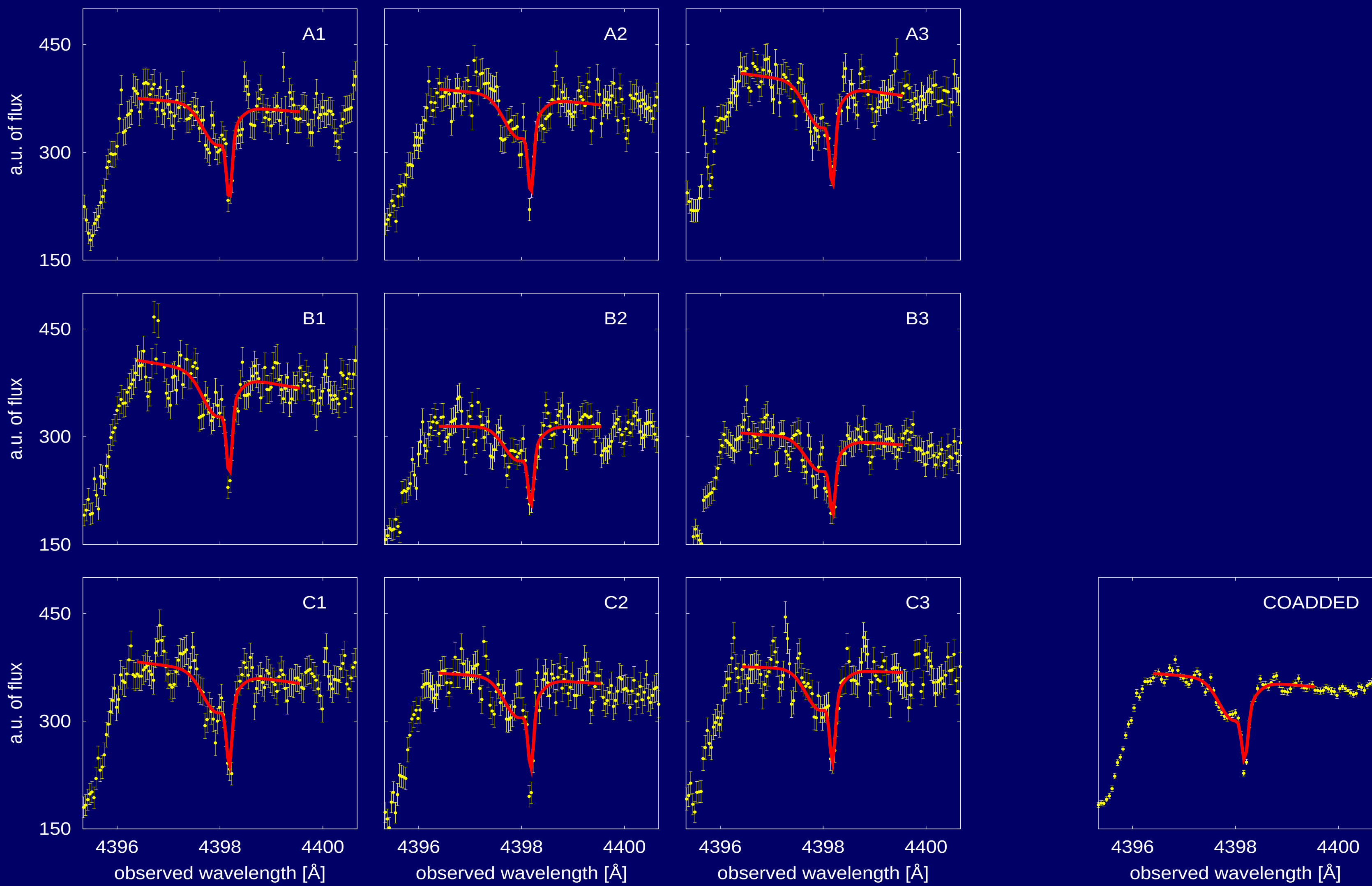
The Ratio of Proton and Electron Masses

FRIEDRICH LENZ
Düsseldorf, Germany

(Received April 5, 1951)

THE most exact value at present[1] for the ratio of proton to electron mass is 1836.12 ± 0.05. It may be of interest to note that this number coincides with $6\pi^5 = 1836.12$.

[1] Sommer, Thomas, and Hipple, Phys. Rev. **80**, 487 (1950).



Nine separately observed spectra with errorbars and exemplary fit of L1R1.


L1P1
L1R1
L2R1
L3R1
L3P1
L4R1
L4P1
L5P1
L5R1
L7R1
L8R1
L9P1
L9R1
L10P1
W2Q1
W3Q1
L13R1
L14R1
A
radial velocity [km/s]