

A NOVEL CALIBRATION OF ATOMIC TRANSITION ENERGIES

A RULER FOR THE ENERGY SCALE

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The logo for Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), consisting of the letters 'FAU' in a stylized, blue, outlined font.

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ERLANGEN CENTRE
FOR ASTROPARTICLE
PHYSICS



Dr. Karl Remeis-
Sternwarte Bamberg

- 1 Why astrophysics needs good laboratory data
- 2 A reliable energy calibration: Experiment
- 3 A reliable energy calibration: Data reconstruction
- 4 Results & Outlook

WHY ASTROPHYSICS NEEDS GOOD LABORATORY DATA

THE OBVIOUS REASON FOR HIGH QUALITY DATA NEEDS

Astrophysics is all about inherently complex objects, so

- Underlying physics need to be well understood.
- Comparison with experimental results gives detailed insights.

Obviously!

Data quality directly influences results.

Wrong quality assessment can lead to false results.

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Example: Radial velocities

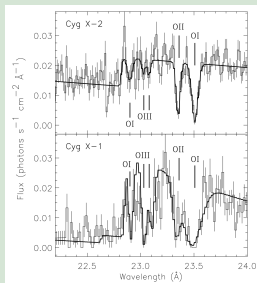


Figure 1: Absorption measurements of galactic sources (Juett et al. 2004).

THE CURRENT AVAILABLE DATA

The problem with the current data

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Back to Oxygen absorption

- Comparison of line positions show ~ 0.5 eV shift \rightarrow Doppler shifted ~ 300 km/s away from us.
- But, same averaged over several line of sight directions.
- And only Oxygen, no other element (we can see).

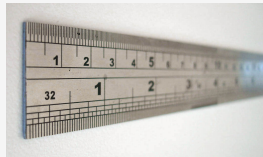
CONCLUSION: OXYGEN IS PUSHED
OUT OF THE GALAXY, OR...

A RELIABLE ENERGY CALIBRATION: EXPERIMENT

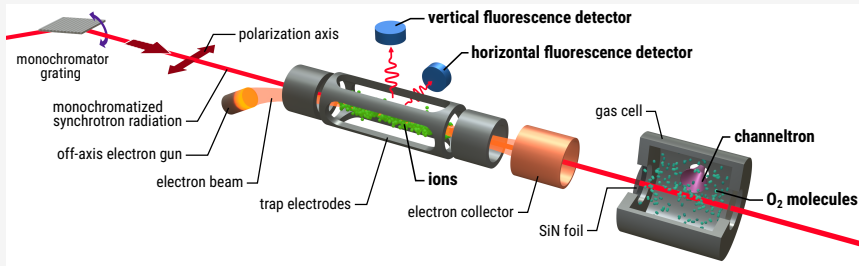
A NEW CALIBRATION IN 3 PARTS

Plan:

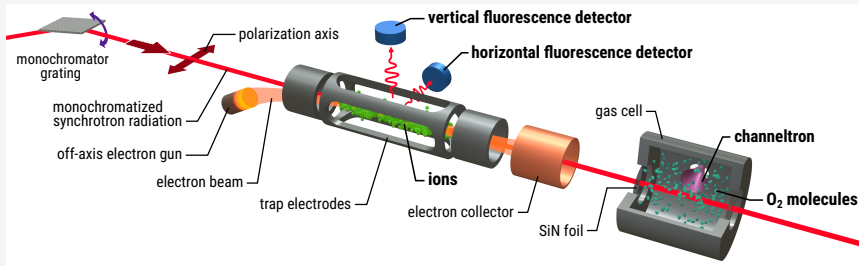
- Construct an experiment which provides a reliable calibration → Make use of Highly Charged Ions (HCIs)
- Calibration simultaneous measured with other experiment → reduce uncertainty
- Utilize synchrotron facilities for high count rate experiments (here BESSY)



EXPERIMENTAL SETUP



EXPERIMENTAL SETUP



Thanks to:
Maurice Leutenegger, José Crespo López-Urrutia, Sonja Bernitt,
Natalie Hell, uvm.

A RELIABLE ENERGY CALIBRATION: DATA RECONSTRUCTION

THE CALIBRATION

Link calibration measurement and molecular data to energy grid

- Ideally, one scan contains line from HCl → known from theory
- Describe HCl data and molecular data with sufficient model
- Link both energy grids with the grating equation

$$\cos \alpha - \cos \beta = \frac{hcN}{E}$$

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Result

Statistical calibration uncertainty: $\lesssim 10$ meV (@ 540 eV)

But only at the HCl transition. Moving away adds systematic uncertainty.

Atomic transition model adds additional uncertainty for line determination.

WHEN ONE CALIBRATION POINT IS NOT ENOUGH

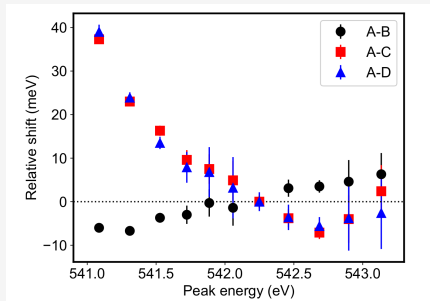


Figure 2: Leutenegger et al. (2020)

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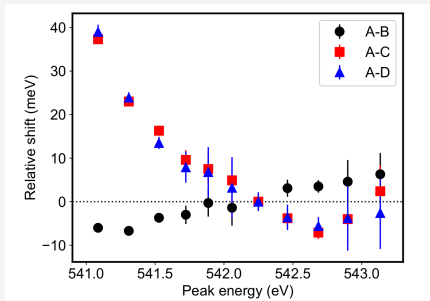
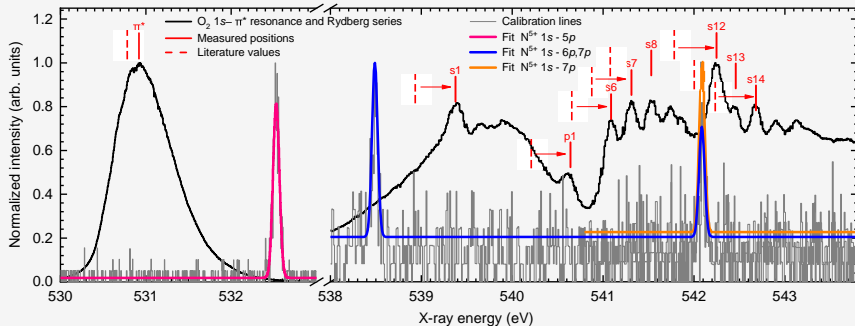


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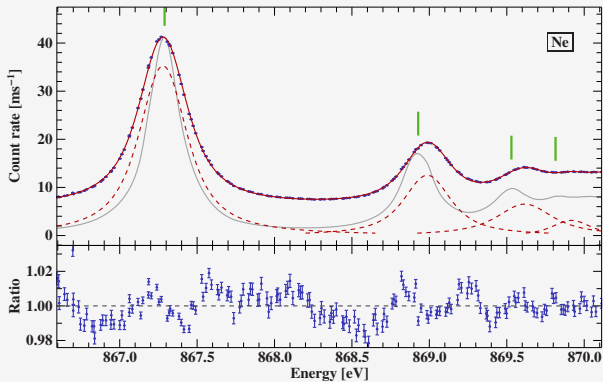


RESULTS & OUTLOOK

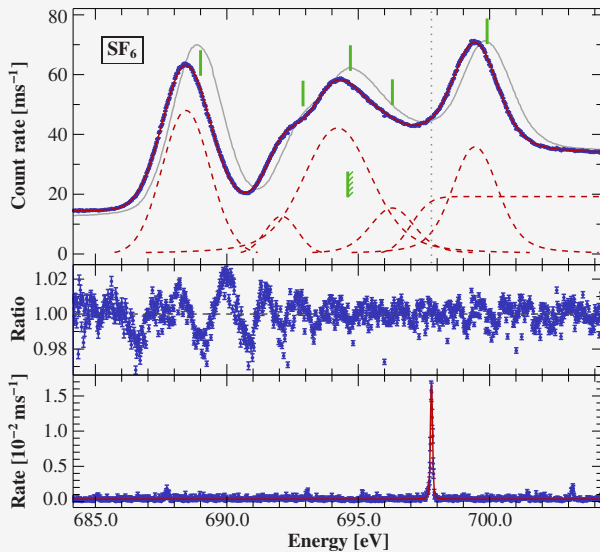
OXYGEN K-EDGE (LEUTENEGGER ET AL. 2020)



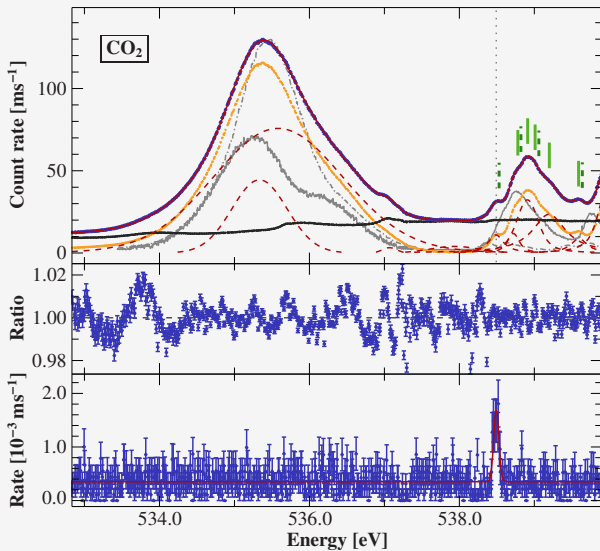
NEON K-EDGE (STIERHOF ET AL. 2022)



SULFUR HEXAFLUORIDE (STIERHOF ET AL. 2022)



CARBON DIOXIDE K-EDGE (STIERHOF ET AL. 2022)



THANKS FOR LISTENING!

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THE POLARX EBIT

PolarX Electron Beam Ion Trap

