STIS Calibration Enhancement

Dispersion solutions based on a physical instrument model

Florian Kerber, P. Bristow, M.R. Rosa, ST-ECF
Outline

- STIS Calibration Enhancement
- Physical Modelling of Instruments
- Input data from the Lamp Project
- Astrophysical Applications and Needs
- Science Demo case
- Summary
STIS Calibration Enhancement (CE)

- Instrument Physical Modelling Group (IPMG)
  - NASA-ESA Memorandum of Understanding (MoU)
  - extension until 2006

- Physical Instrument Models
  - Optical configuration
  - CCD charge transfer

- Laboratory Standards
  - Lamp project
  - Funded by ESA
Optical Model: Summary

- Engineering information (optical design)
- Streamlined ray trace
- Monte-Carlo illumination of slit
- Simulated Data
- Parameter Space
Wavelength Calib

- **Package:**
  - Optical Model
  - Data on Optical Materials
  - Calibration Line lists
  - Simulated Data
  - Close loop between Model-Observation

**Next step**

Paul’s talk
Lamp Project

- **Instrument Physical Modelling Group**
  - M. Rosa, P. Bristow, F. Kerber (A. Alexov, M. Fiorentino)
  - NIST Atomic Spectroscopy Group
  - J. Reader, G. Nave, C. Sansonetti

- **STScI**
  - P. Goudfrooij et al. Spectrograph’s Group
  - D. Macchetto (ESA)

- **HST Project and STIS IDT (GSFC)**
  - M. Niedner and B. Woodgate
Hollow cathode lamp
Results of ST-ECF Lamp Project

- Measure spectrum of Pt/Cr-Ne lamp at NIST: 110 - 320 nm
- Derive an accurate (< 1/1000 nm) list of wavelengths as input for STIS-CEs
  - FUV: 1123 lines total currently 95% identified; 235 Cr, Sansonetti et al. 2004, ApJS, 153, 555
  - NUV: >7000 lines, ~5000 Cr, Kerber et al., 2006 in preparation
STIS-CE Lamp Project

- Impact of the Cr lines strongest in the NUV
- List of > 5000 lines,
- $\lambda$ accurate to < 1/1000 nm
- Replace 2-D polynomial fit by STIS physical model - more accurate and more homogeneous solution across the whole chip

Echelle, $\lambda_c \approx 251.3$ nm

# of lines: Pt-Ne 258 vs Pt/Cr-Ne 1612
### Chromium

- **Studies of the ISM and fundamental physics**

<table>
<thead>
<tr>
<th></th>
<th>Morton 1991 $\sigma \pm 0.002$ Å</th>
<th>Pickering et al. 2000 $\sigma \pm 0.0001$ Å</th>
<th>Our work $\sigma \pm 0.0001$ Å</th>
</tr>
</thead>
<tbody>
<tr>
<td>2056.254 Å</td>
<td>2056.2569 Å</td>
<td>2056.25679 Å</td>
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<tr>
<td>2062.234 Å</td>
<td>2062.2361 Å</td>
<td>2062.23596 Å</td>
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<td>2066.161 Å</td>
<td>2066.1640 Å</td>
<td>2066.16387 Å</td>
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Fundamental Physics

- Fine Structure constant
  \[ \alpha = \frac{e^2}{2\varepsilon_0 hc} \approx 1/137 \]

Astrophysics
- Interstellar absorption lines in QSO spectra
- \( \frac{\partial \ln \alpha}{\partial t} = (6.4 \pm 1.4) \cdot 10^{-15} \)
  \[ 0.2 < z < 3.7 \]
- Murphy et al., 2003, Quast et al. 2004

Atomic Physics
- Single \( ^{171}\text{Yb}^+ \) Ion in Pauli trap for 2.8 years
- \( \frac{\partial \ln \alpha}{\partial t} = (-0.3 \pm 2.0) \cdot 10^{-15} \)
- Peik et al., 2004, Phys. Rev. Lett., 93(17)
STIS Dispersion Model projected onto E140H short Auto-Wavecal

original

smoothed (3*3 gaussian)
STIS Dispersion Model E140H

best solution
$\sigma \sim 0.4$ pix

not so good solution
$\sigma \sim 3$ pix
Science Demo Case

- Interstellar absorption lines
- C I Fine Structure excitation
- \( R \sim 200,000, \ E_{140H} \ & \ E_{230H} \)
- Noted discrepancies between wavelengths of same lines in adjacent order
Science Demo Case
Science Demo Case

HD 210839
Science Demo Case: Result

Standard: $\Delta \lambda = -0.00326 \pm 0.00194 \text{Å}$

STIS-CE: $\Delta \lambda = -0.00060 \pm 0.00169 \text{Å}$
HD 210839 interstellar lines STIS E140H

indicating 4 velocity families of absorption
STIS-CE Summary

- Highly accurate Pt/Cr-Ne line list
- 115 - 320 nm, >11000 lines, >5000 Cr
- CTI physical model, 2D capability
- Model based dispersion solution
- Factor of five improvement possible