Accounting for Chromatic Atmospheric Effects on Barycentric Corrections

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6▫13▫2017

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ERES III

Barycentric Correction → Transform observed radial velocities to a frame that is at rest WRT the barycenter of the solar system

$$z_{\text{true}} = (1 + z_{\text{meas}})(1 + z_B) - 1$$

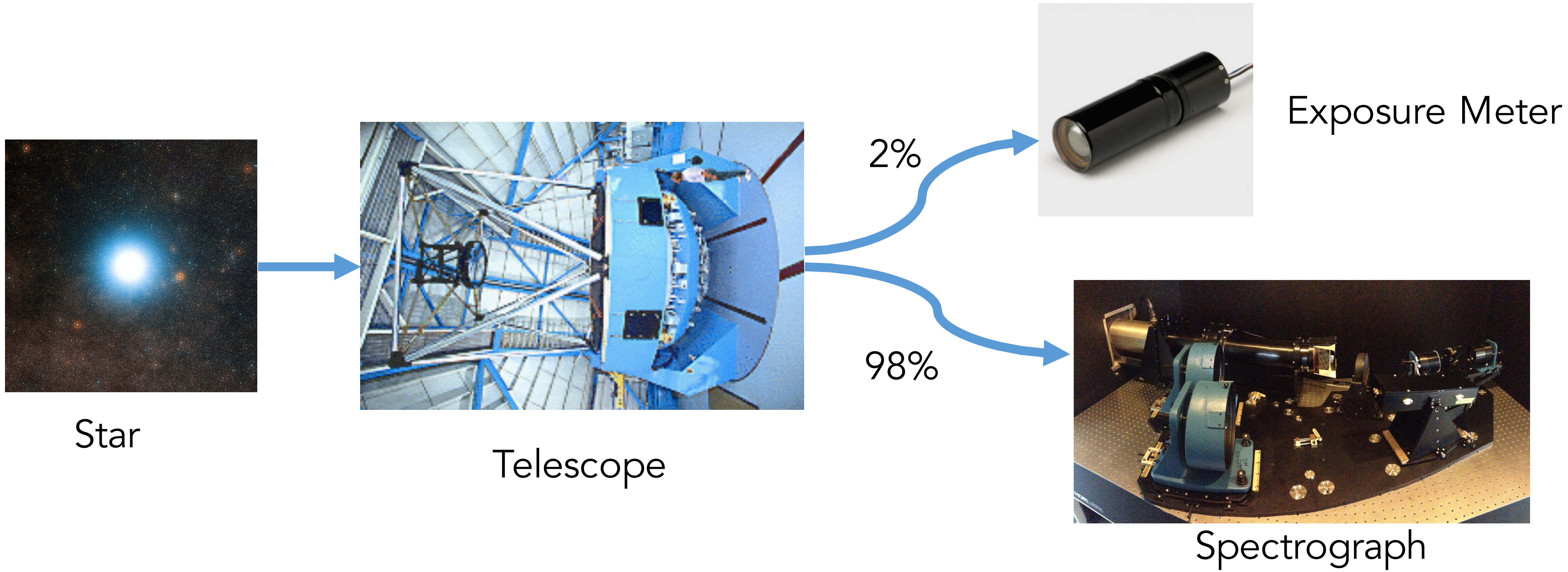
Need the time of observation for accurate barycentric corrections

$$z_B \approx \left(\gamma_\oplus \frac{1 + \vec{\beta}_\oplus \cdot \hat{\rho}}{1 + z_{\text{GR}}}\right)\left(\frac{(1 + \vec{\beta}_s \cdot \hat{r}_0)}{1 + \vec{\beta}_s \cdot \hat{\rho}}\right) - 1 - z_{\text{LT}} - z_{\text{SD}}$$

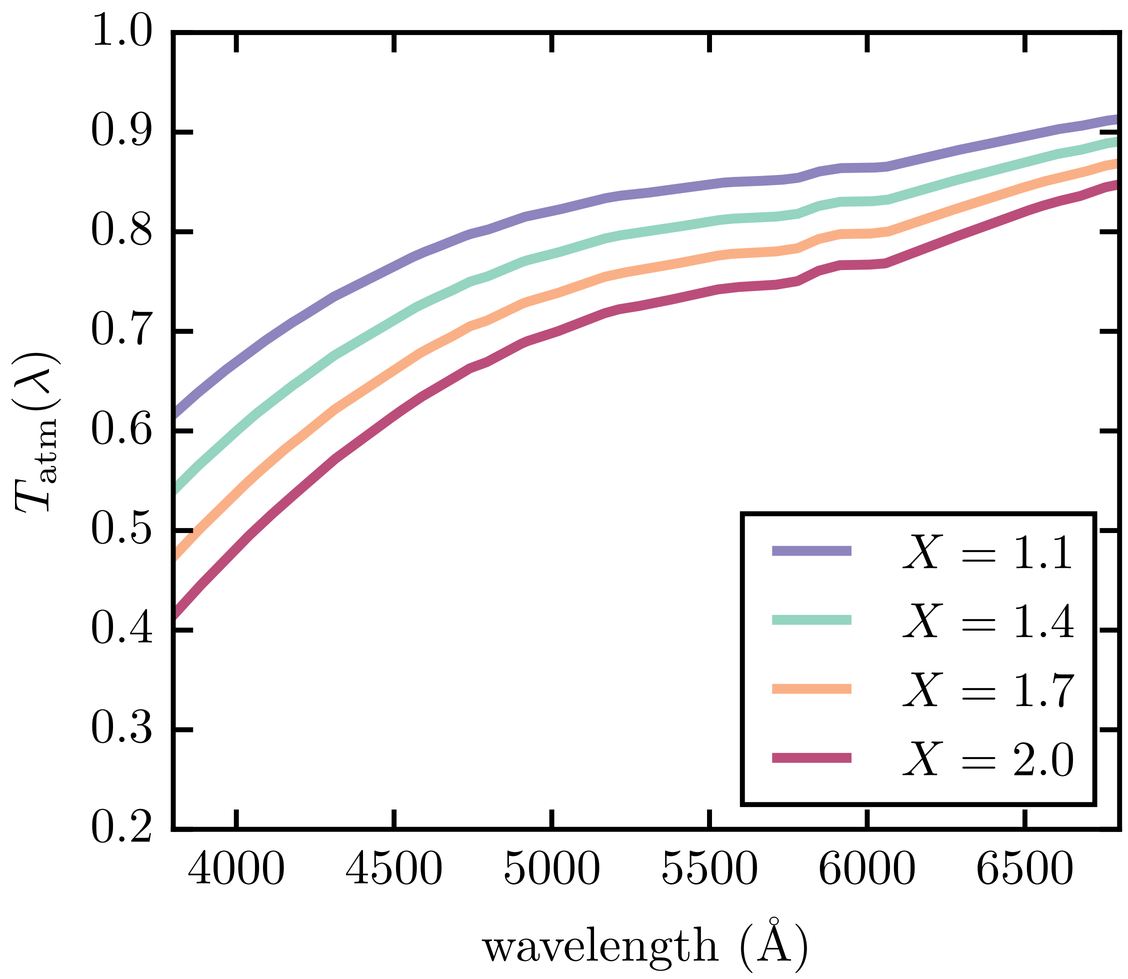
All changing in time!

Wright & Eastman 2014

Exposure Meter ➡ Measures flux throughout an observation so that the barycentric correction can be weighted



Atmospheric transmittance changes as a function of air mass and wavelength



$$T_{\mathrm{atm}}(\lambda) = e^{-X\kappa(\lambda)}$$

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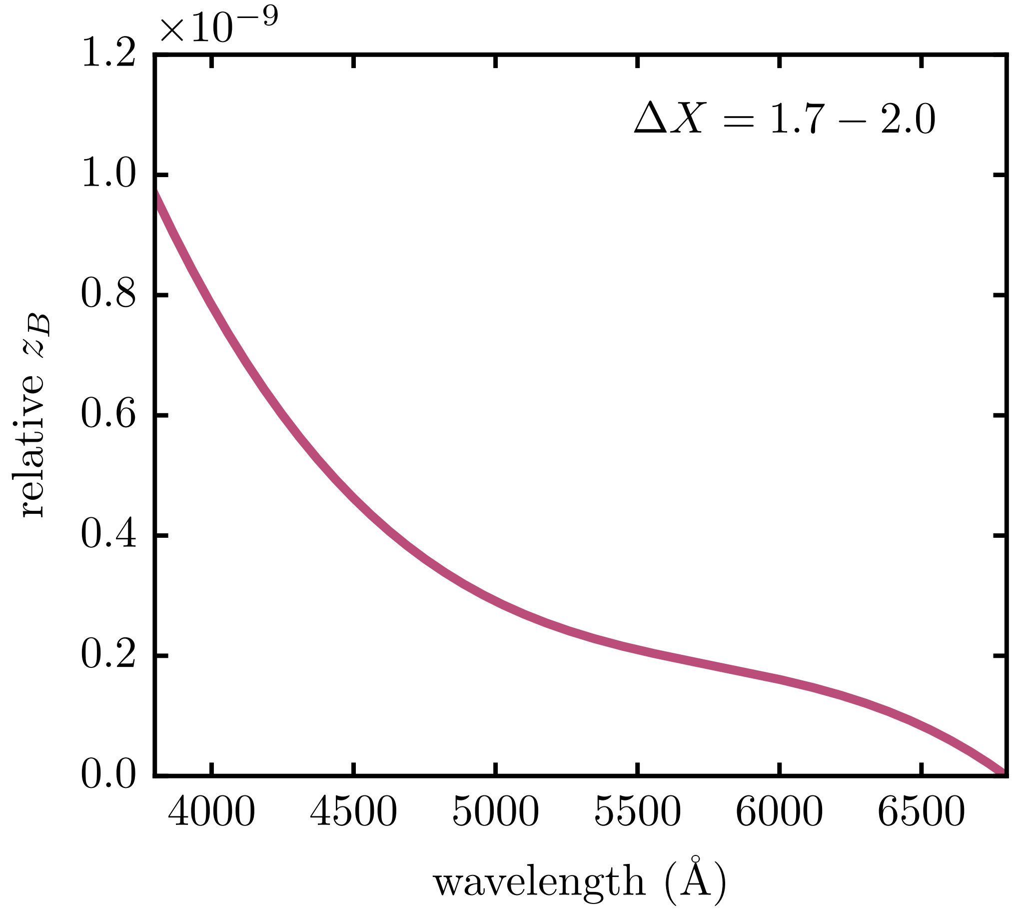
The barycentric correction is a function of wavelength!

$$\cancel{z_{\text{true}} = (1 + z_{\text{meas}})(1 + z_B) - 1}$$

$$\Downarrow$$

$$\boxed{z_{\text{true}} = [1 + z_{\text{meas}}(\lambda)][1 + z_B(\lambda)] - 1}$$

Chromatic atmospheric impact on barycentric corrections from simulated observations



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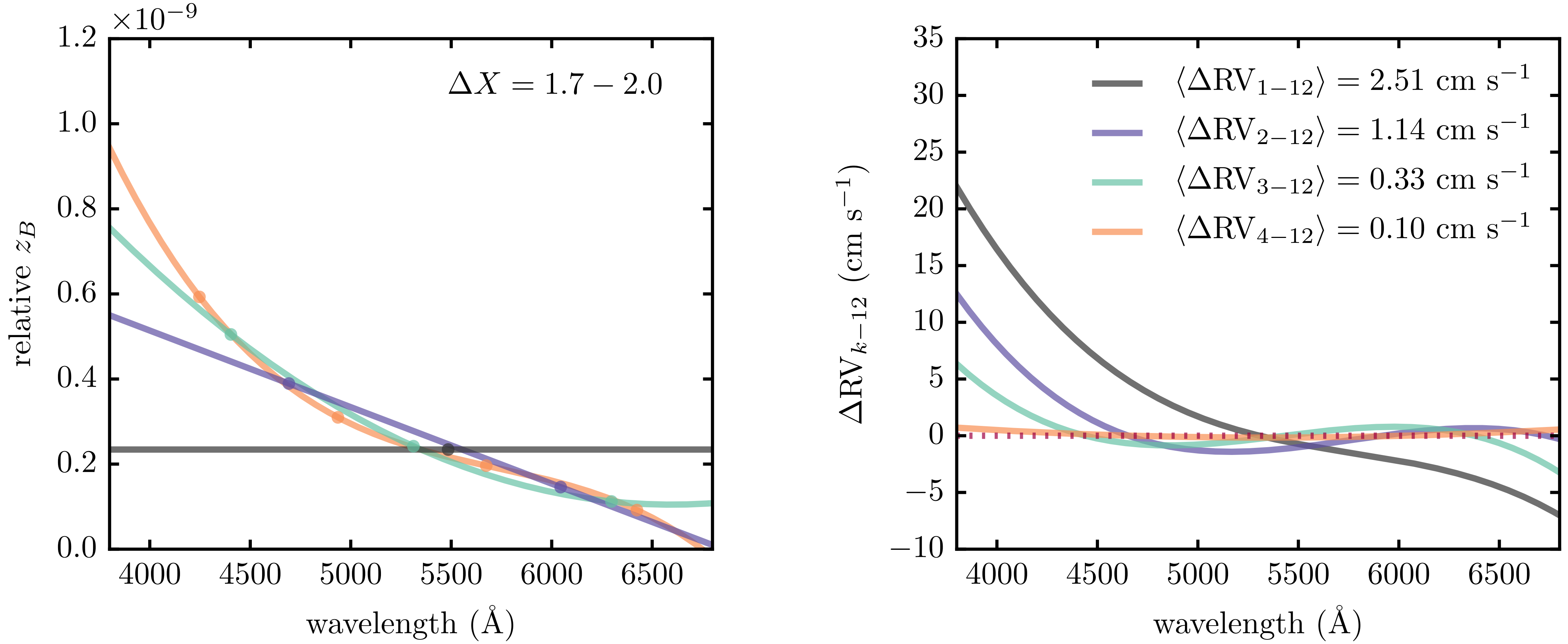
Chromatic atmospheric impact on barycentric corrections from simulated observations



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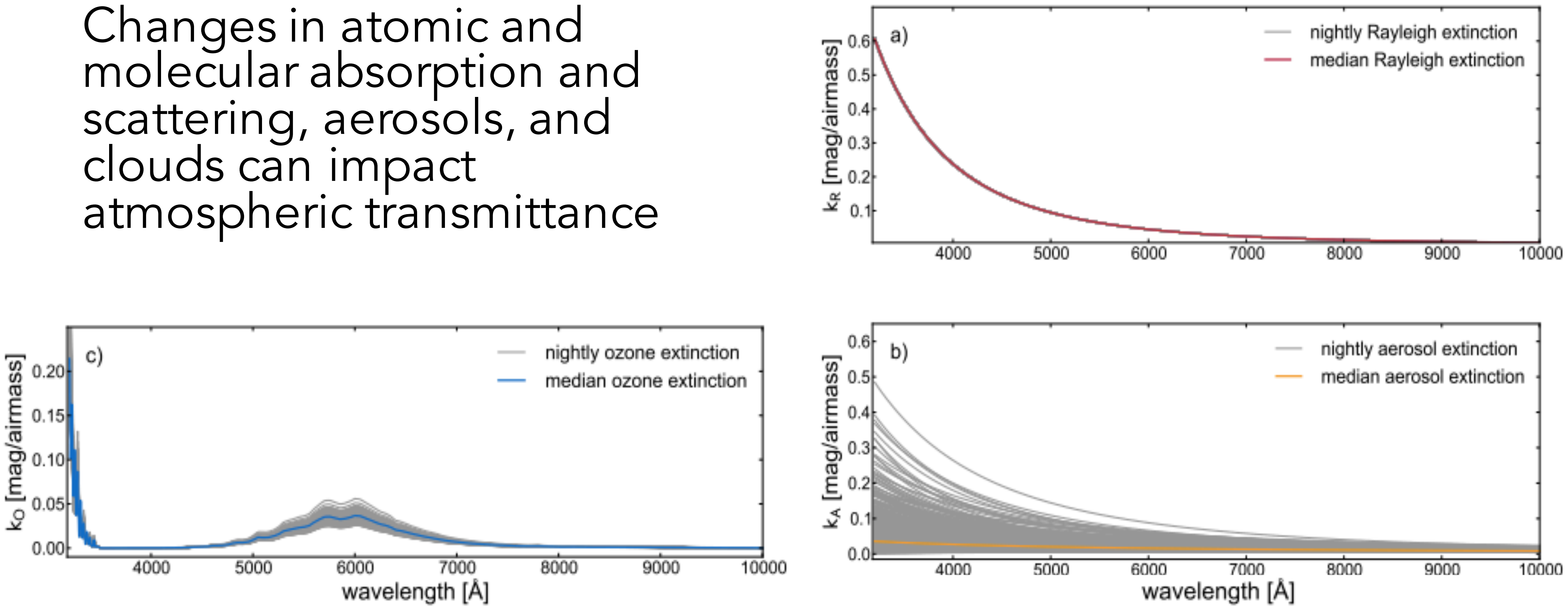
Variations in components of atmospheric attenuation

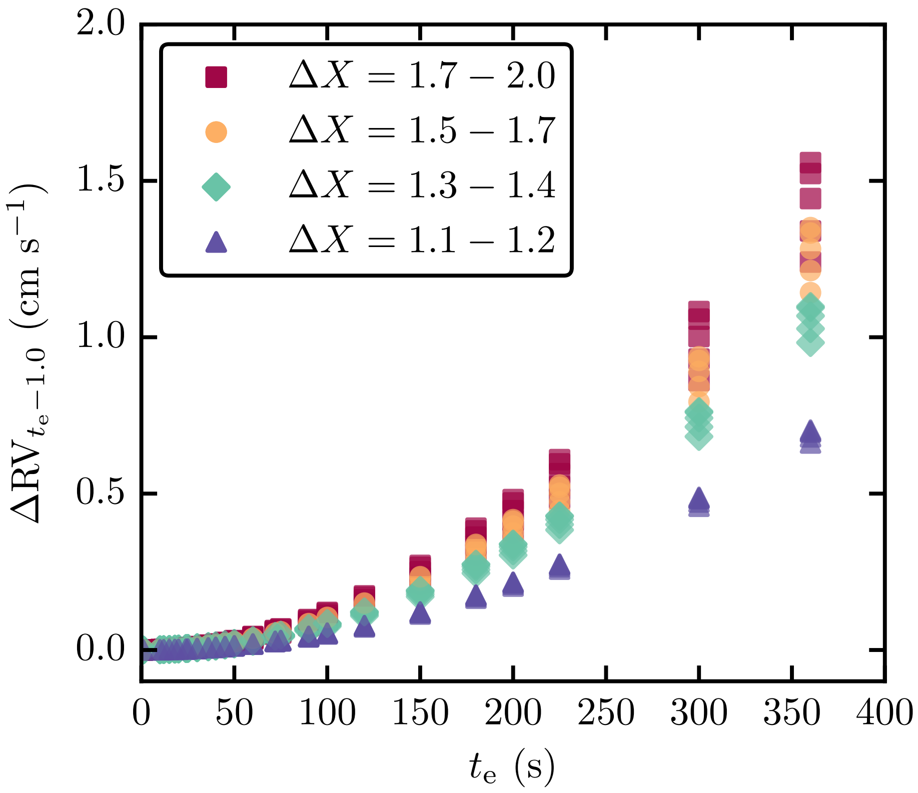
Changes in atomic and molecular absorption and scattering, aerosols, and clouds can impact atmospheric transmittance



Buton+ 2013

Exposure meter integration error

We choose an integration length for the exposure meter, and assume all photons arrived at the midpoint of each integration



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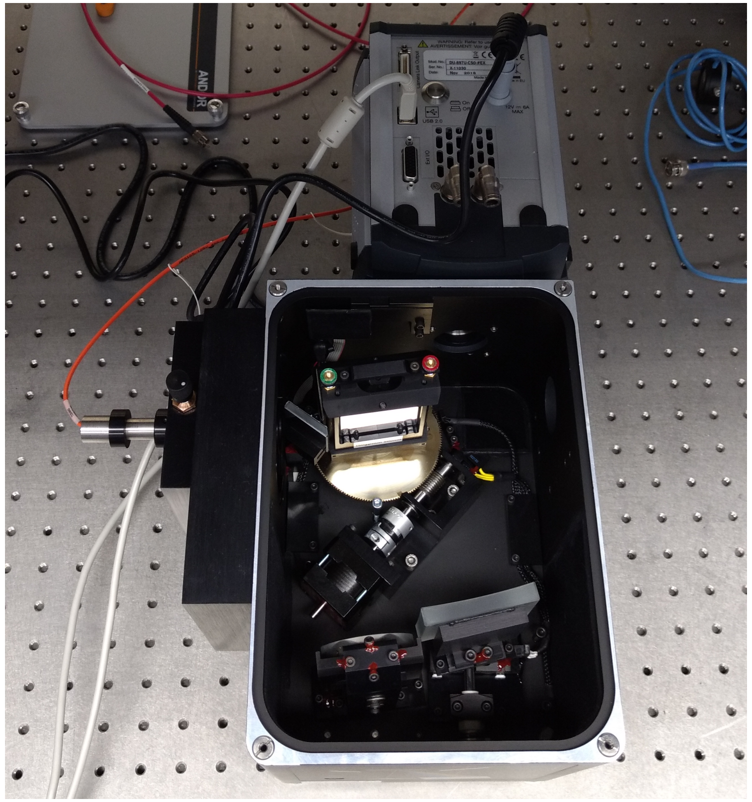
Summary

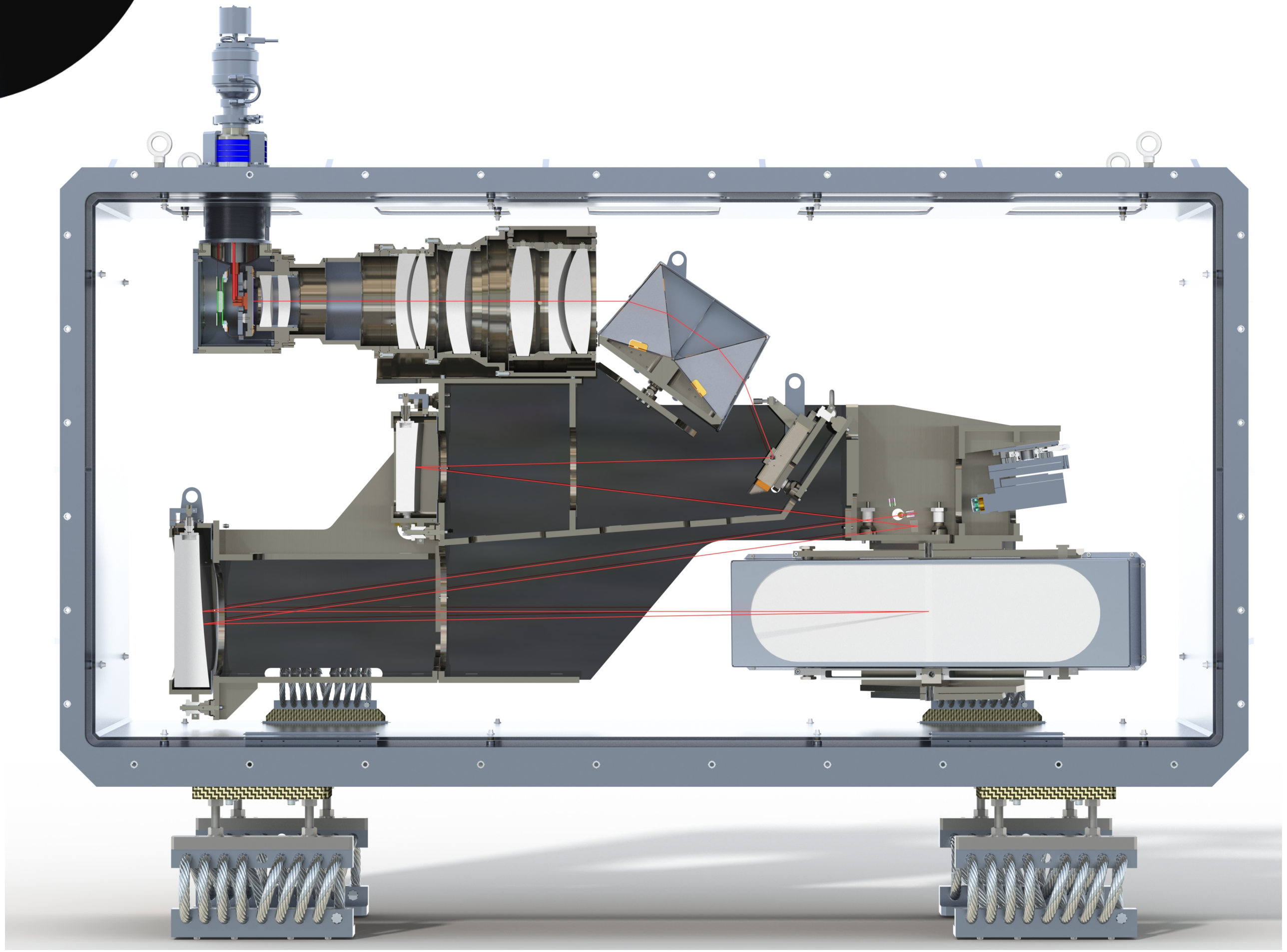
- Accounting for chromatic atmospheric effects on barycentric corrections is important for precision radial velocity measurements for exoplanet discovery and characterization
- Use of a multiple-channel exposure meter with at least four wavelength channels and integration times on the order of seconds can account for these effects

EXPRES
Search for 100 Earths

EXPRES exposure meter



R = 250



R = 150,000