OODF: Optimized Opacity Distribution Functions for a New Generation of Solar and Stellar Brightness Variability Models

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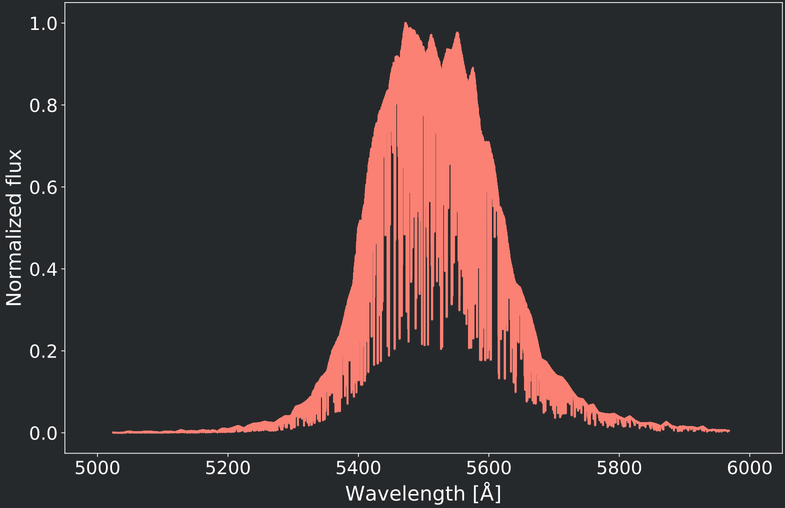
Exemplary case of Strömgren *y* filter

- Complex structure of spectrum due to lines

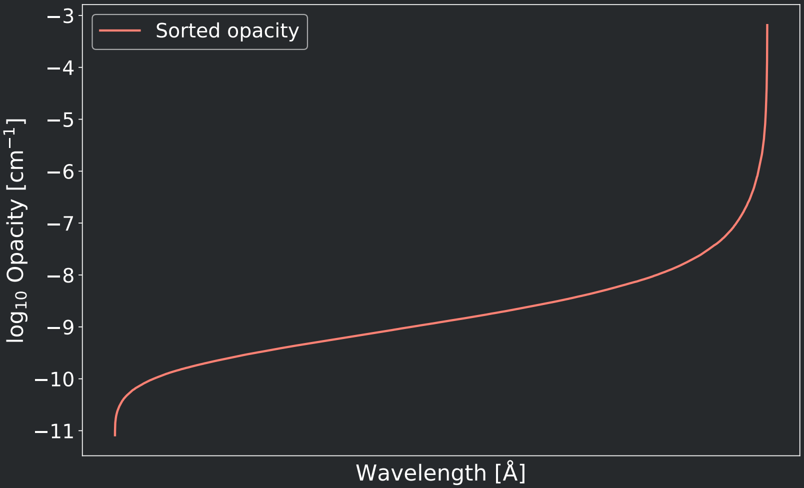


Complex structure of opacity

- Opacity varies by multiple orders of magnitude within 1Å

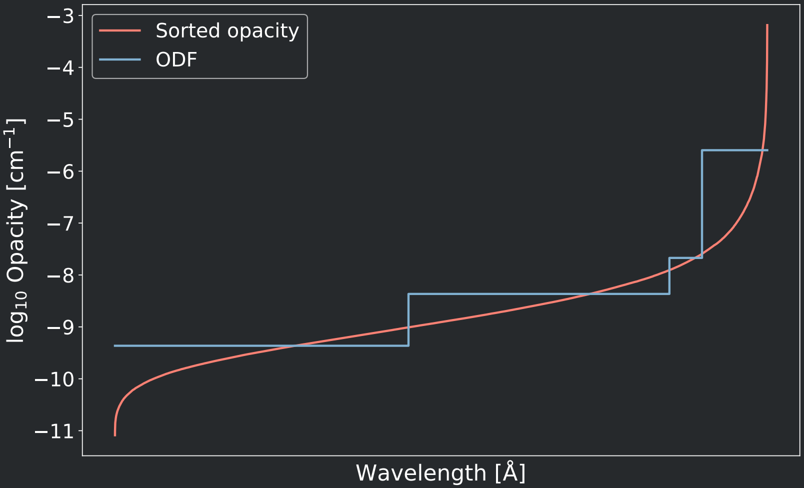
Sorting by opacity

- Sort wavelength points by corresponding values of opacity



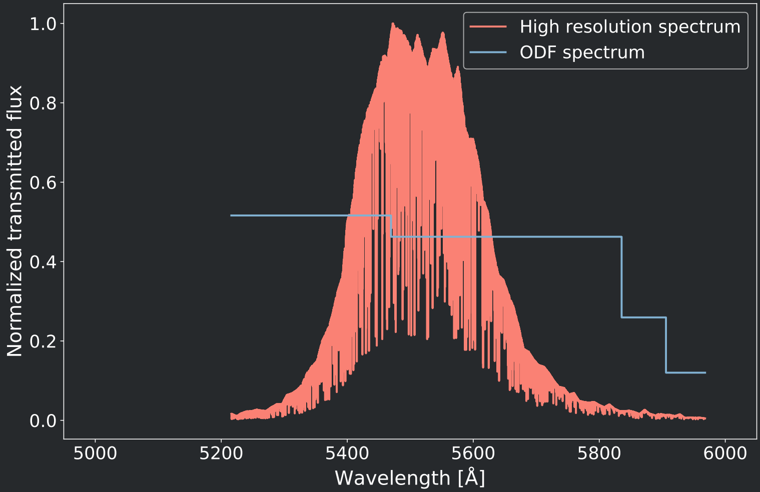
Approximating the sorted values

- Approximate opacity with a stepwise function



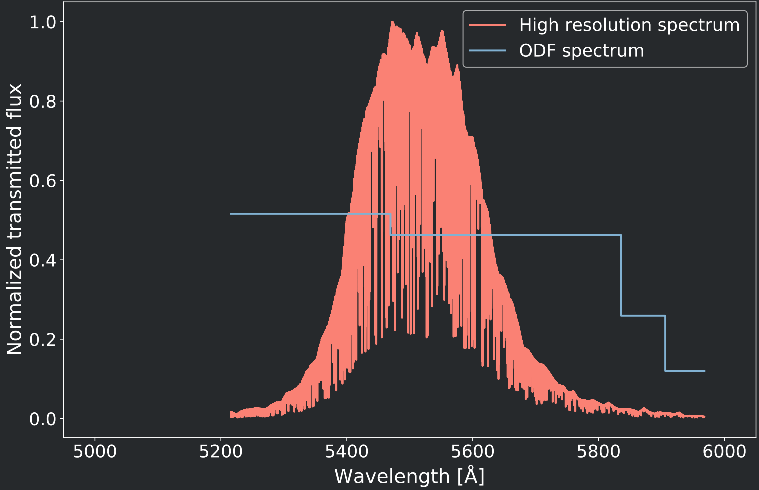
High resolution spectrum and ODF spectrum

- Use the stepwise opacity to calculate the flux



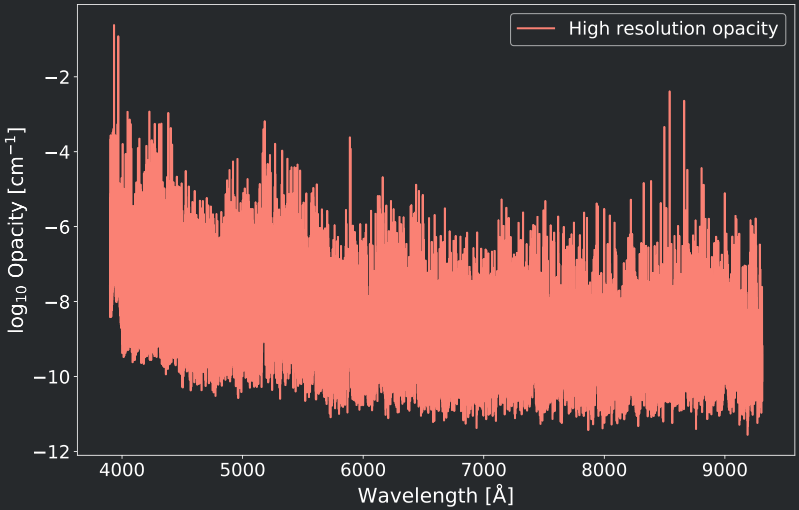
High resolution spectrum and ODF spectrum

- Use the stepwise opacity to calculate the flux
- 4 sub bins -> This two integrals differ by just 2%



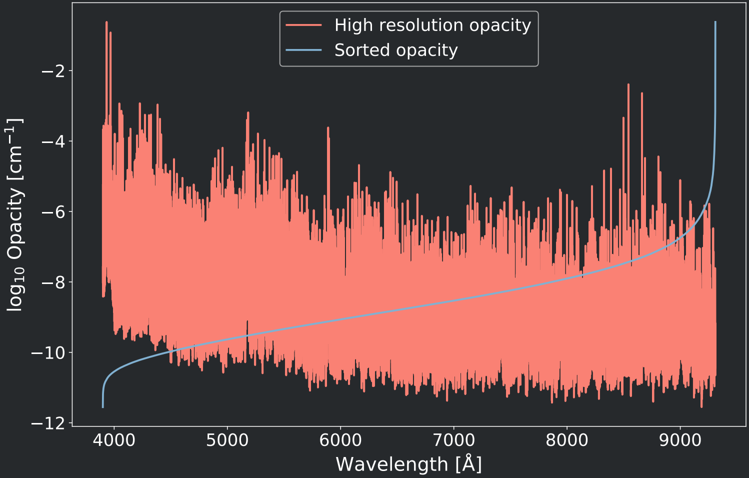
Generating ODFs

- Start with high resolution opacity



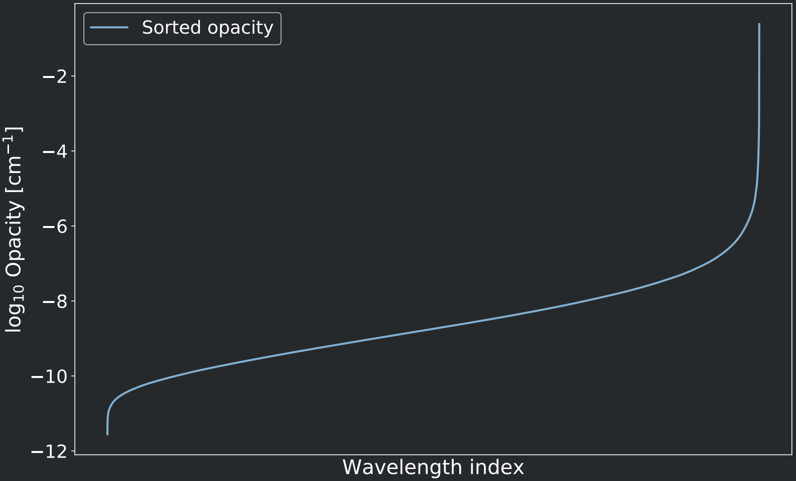
Generating ODFs

- Sort wavelength points by corresponding values of opacity; monotonically increasing opacity
- Integral is preserved by sorting



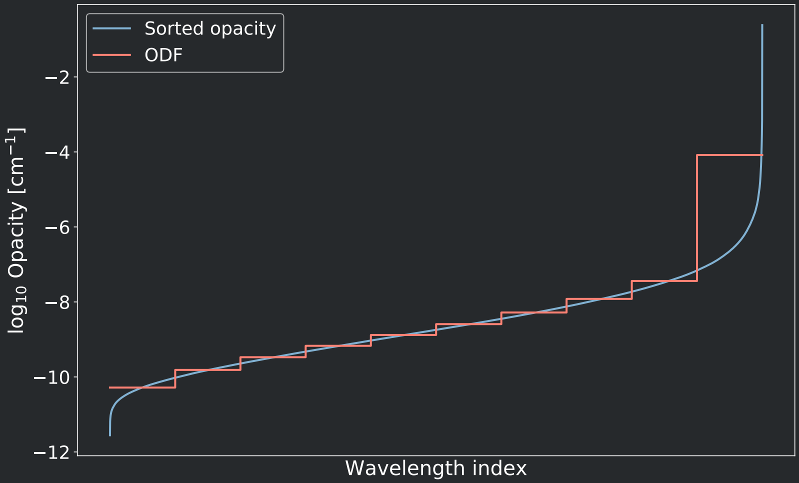
Generating ODFs

- All wavelength information within the bin is lost



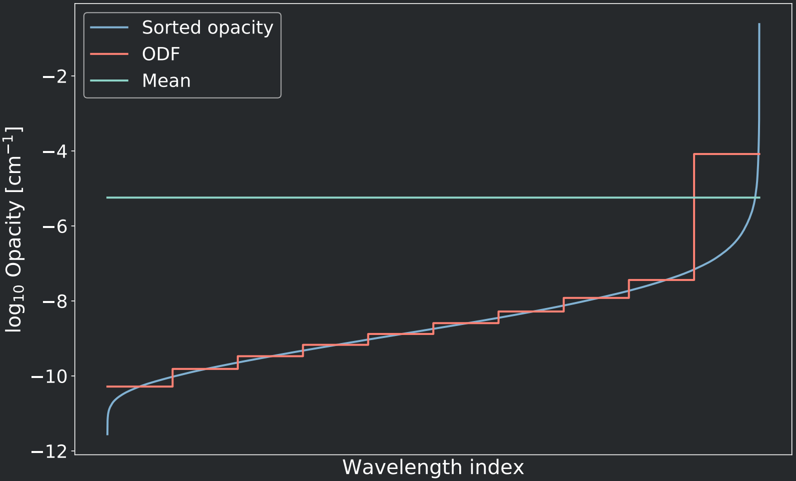
Generating ODFs - Example with 10 uniform sub bins

- Approximate the sorted opacity with a step-wise function



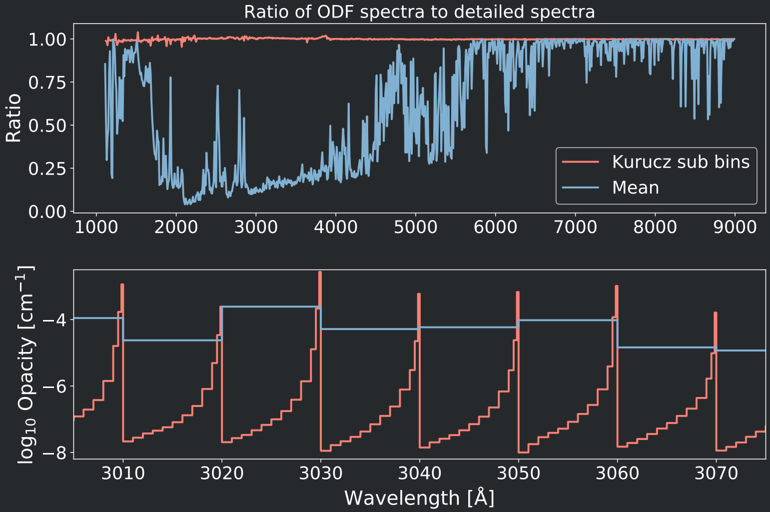
ODF generation process

- Mean is skewed by extreme values



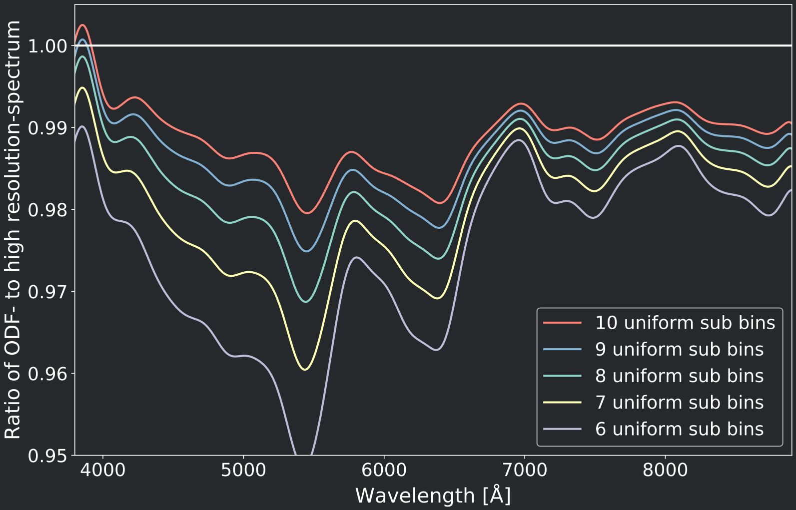
ODF performance analysis

- Synthesize spectrum using ODFs from 1000-9000Å with 10Å bins
- Compare the fluxes from the ODF spectrum with the high resolution spectrum in the bins



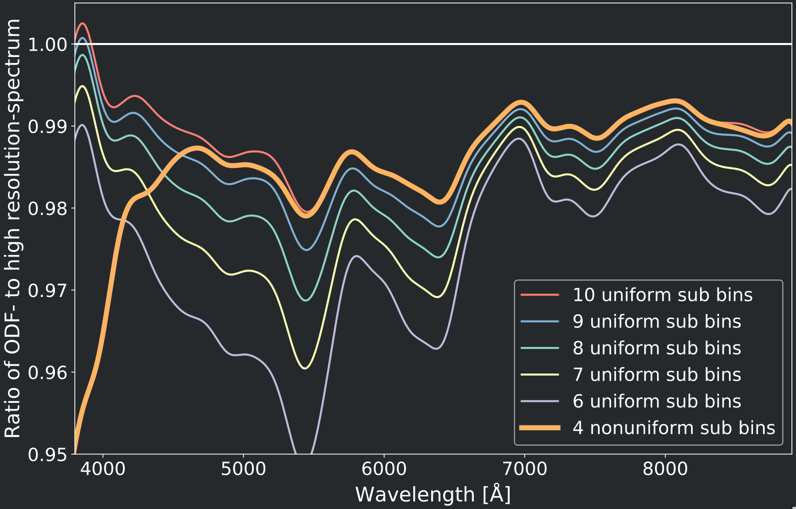
Analysis of different ODFs

- Uniform ODFs



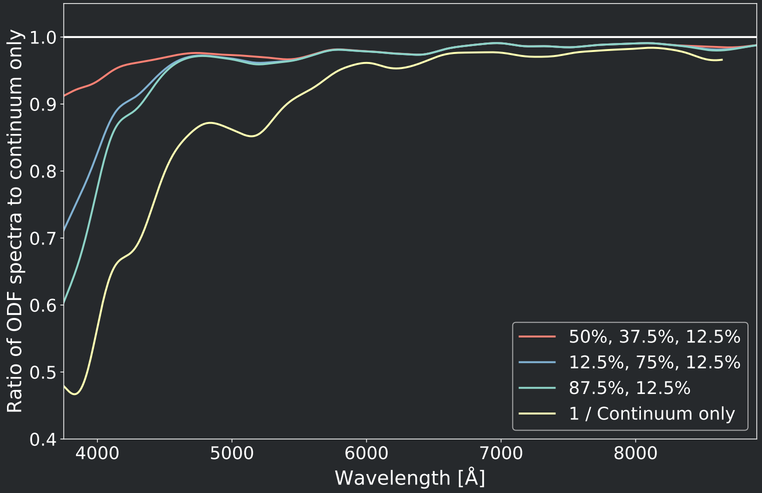
Analysis of different ODFs

- Nonuniform ODFs
- The last sub bin is crucial after 5000Å

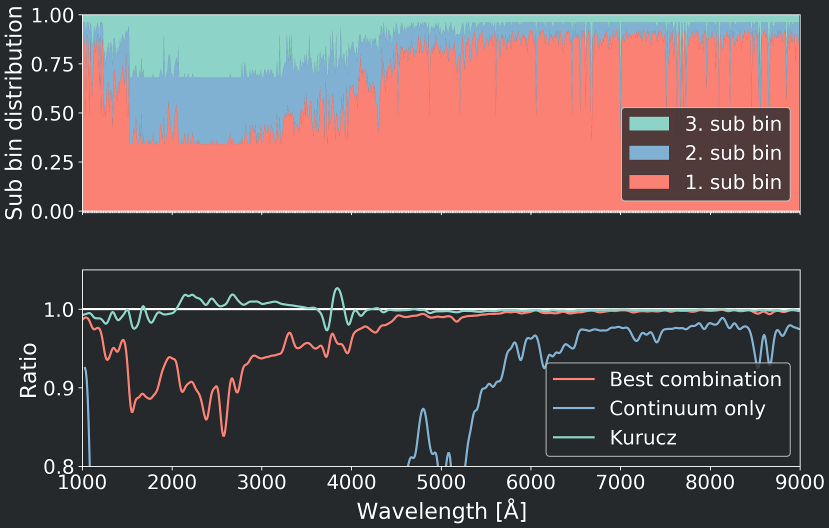


Comparison of nonuniform sub bins

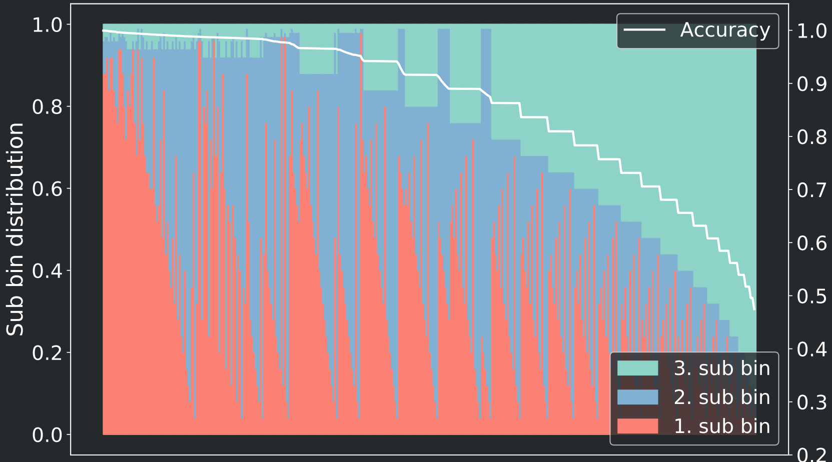
- Legend specifies sub bin sizes, starting with the first one
- Last sub bin is the same for all



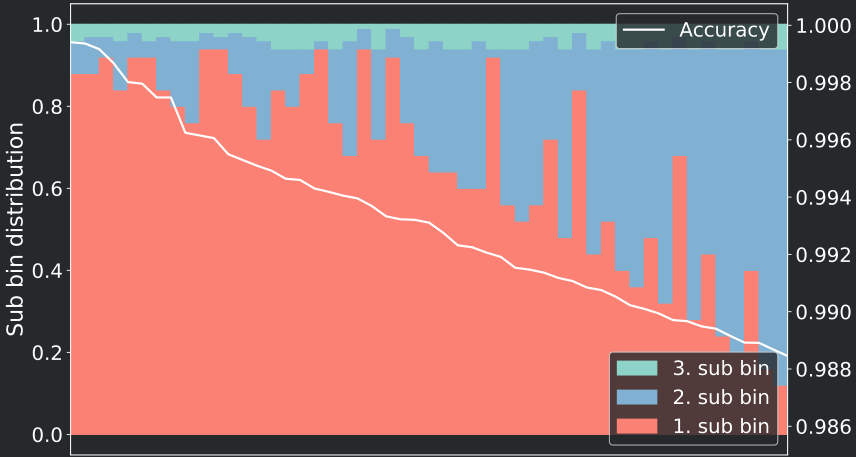
Best sub bin combinations using 3 sub bins



Best combinations of 3 sub bins for Strömgren y



Best combination of 3 sub bins for Strömgren y



Speedups in the case of Ströemgren *y*

- Interval length: ~1000Å

High resolution: 80 points per Å ~ 80 000 points

ODF: 12 points per 10Å ~ 1200 points
speedup 67 times

OODF: 3 points per 1000Å ~ 3 points
speedup 25 000 times

Conclusions

- An efficient procedure for radiative transfer is timely for new generation of solar and stellar variability models.
- We developed a novel method for fast spectral synthesis.
- Can be tailored for different filters: Strömgren $b + y$, Kepler, PLATO and others.
- Significant speed up relative to standard methods by a factor of at least two orders of magnitude.

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Thank you for your attention!