Extinguishing starlight from absorption lines

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1) Motivation

Dust dims light through **extinction**—absorption and scattering along the line of sight. Since shorter wavelengths are affected more, sources appear redder.

How can we quantify extinction?

In the interstellar medium, the line strengths of certain elements (e.g., Na I and Ca II) measured from high-resolution spectroscopy correlate with dust extinction.

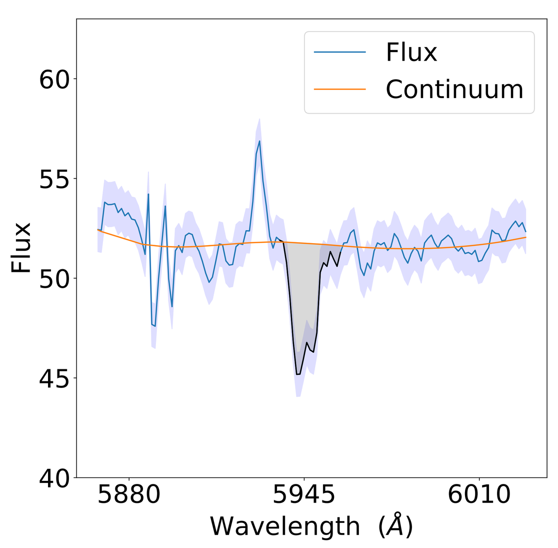

Figure 1: Line measurement.

Goal: Study interstellar extinction using spectral absorption features in spectra.

Why this matters: In the case of Supernova (SN) spectra, these absorption features can arise from the interaction of explosion light with:

- the interstellar medium (ISM), or
- the circumstellar material (CSM) from the progenitor.

Disentangling both contributions is essential to better understand both the progenitor system and the galactic environment.

2) Dataset

We analyse the host-galaxy and SNe spectral data:

Galaxy data

- The AMUSING survey gives Integral Field Spectroscopy (IFS) data — spectra at each pixel across the galaxy.
- Enables spatial studies of ISM abundance and kinematics across the galaxy.

SNe spectral data

- Single sightline towards the SN.
- High resolution reveals narrow absorption components, enabling detailed studies of the ejecta and the intervening material.

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The simultaneous analysis of both presents a unique opportunity to

- Disentangle atypical nearby dust from global diffuse galactic dust.
- Constrain SN progenitors and their galactic environments.

In the next ESO Call for Proposals, we will request *X-shooter* observations of high-resolution SN spectra in AMUSING galaxies.

3) Preliminary Results

We apply Voronoi binning to group the data into regions of equal signal-to-noise ratio (SNR).

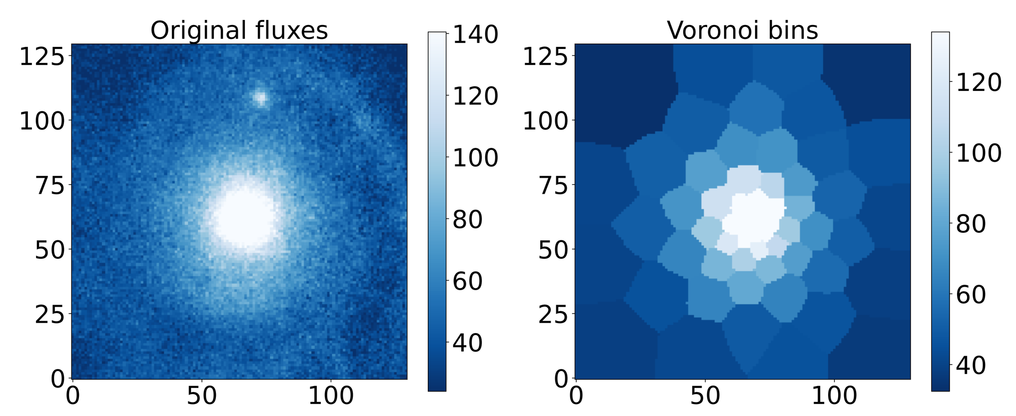

Figure 2: Voronoi binning of NGC3244 at Sodium wavelength.

The strength of a spectral line is quantified by its Equivalent Width (EW):

$$\mathrm{EW} = \sum_i \frac{c_i - f_i}{c_i} \Delta\lambda,$$

where c is the continuum and f is the flux. To test our methods, we measure the EW of the Milky Way absorption line in each bin.

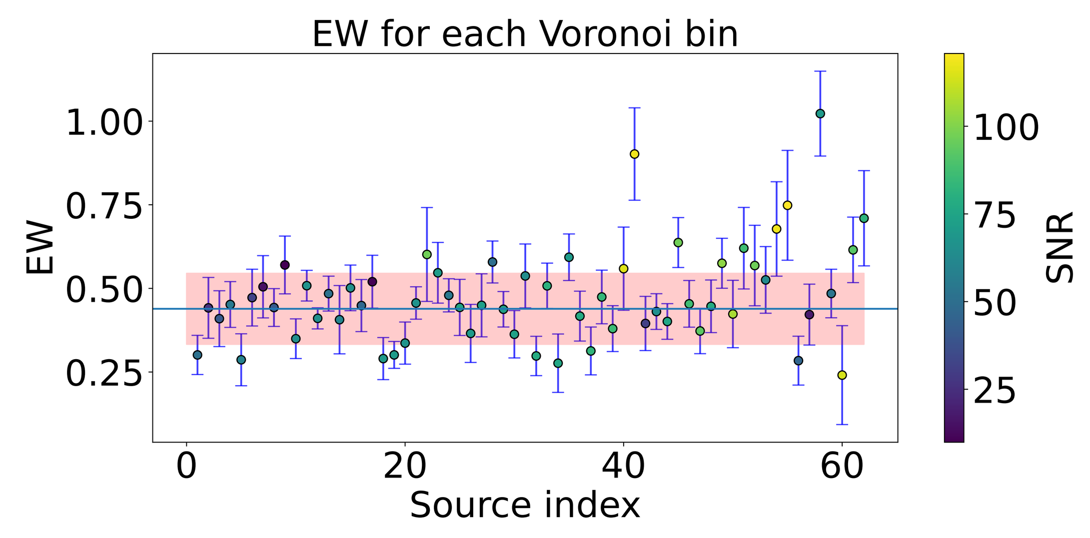

Figure 3: EW values for each Voronoi bin.

The line-of-sigth velocity of a spectral line is measured by:

$$\mathrm{v(km\ s^{-1})EW} = \frac{c}{\lambda_{\mathrm{rest}}} \left[\frac{\sum_i (1 - f_i/c_i)\lambda_i}{\sum_i (1 - f_i/c_i)} - \lambda_{\mathrm{rest}} \right]$$

Tracing elements like H_α reveals galaxy rotation. This helps determine whether observed line shifts in SN spectra are due to local CSM or galaxy motion.

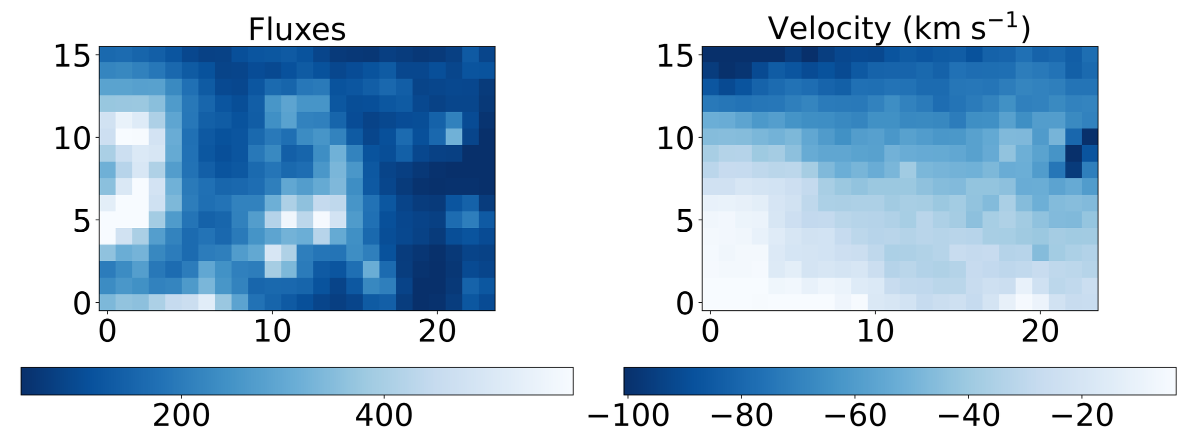

Figure 4: Velocity map of H_α in NGC 3244.

4) Ongoing Work

For SNe occuring in AMUSING galaxies:

- Study EW time evolution of absorption lines in Type Ia SNe → Probe outflows or photoionization from nearby material.
- Combine SN spectra with SKIRT radiative transfer models → Compare modeled host extinction with observed line-of-sight extinction.
- Use extinction mismatch to infer the depth of the SN's position within host galaxy → New approach to locate SNe relative to dust geometry.

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