3D datacube reconstruction using *Roman* slitless prism spectra

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Datacube reconstruction for host galaxy subtraction

- One of Roman’s objectives is to study Dark Energy using Type Ia Supernovae (SNe Ia).
- However, when observed using slitless spectroscopy, the spectra of SNe Ia will be contaminated by their host galaxies.
Datacube reconstruction for host galaxy subtraction

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Datacube reconstruction for host galaxy subtraction

- Obtaining clean, uncontaminated SN Ia spectra allows us to accurately determine their luminosity distances and intrinsic brightnesses.
Datacube reconstruction for host galaxy subtraction

- Our approach is to develop a datacube reconstruction algorithm that uses the host galaxy spectra observed at various roll angles and dithers:

- The reconstructed datacube can then be used to predict what a galaxy spectrum would look like when a supernova occurs.
Regularized regression and the projection model

- We infer the fluxes in the datacube using Ridge regression:
  \[
  \min_f ||\phi f - I||^2 + \alpha ||f||^2, \tag{1}
  \]
  with the regularization parameter \(\alpha\) found by cross-validation.

- A slitless 2d-spectrum is a projection of not only wavelength but also position. We can construct the projection model.
A measured count $I_{ij}$ in pixel coordinates $(i, j)$ is a summation of fluxes $f$ in the datacube:

$$I_{ij} = \sum_{l=l_{\text{min}}(j)}^{l=l_{\text{max}}(j)} A_{\text{eff}}(l) \Delta \lambda(l) [h(l) \ast f(l)],$$

(2)

The flux $I_{ij}$ is in principle a linear summation of fluxes in spatial coordinates (due to convolution) and wavelength (due to dispersion):

$$I_{ij} = \sum_{r} \phi(\mathbf{x}) f_{r},$$

(3)

here $\phi(\mathbf{x})$ is the basis function at scene coordinate $\mathbf{x}$. 
Constructing galaxy datacubes

- Galaxy datacubes are constructed using SDSS images as templates.
- To construct spectrum at each point in the galaxy, we use redshift-dependent star formation models.
Predicting Galaxy-only spectra at random roll angles
Predicting Galaxy-only spectra at random roll angles
Predicting Galaxy-only spectra at random roll angles
Predicted SN-only spectra at random roll angles

Predicted - True [ADU]

Fractional error

X [pix]
Y [pix]
Predicted SN-only spectra at random roll angles

Count [ADU]

X [pix]
Summary and conclusions

- We address the problem of obtaining clean SN Ia spectra by reconstructing the host galaxy datacube from a set of spectra observed at various roll angles and dithers. Using the reconstructed datacube, we can predict what the host galaxy spectrum would look like when a supernova occurs.
- Because there are more parameters (fluxes in 2d space and wavelengths) than there are data (pixels), datacube reconstruction is an ill-posed problem. Some form of regularization is essential.
Next steps

- We are trying to reduce this uncertainties further by constructing datacube priors from set of images taken in conjunction with the spectroscopic survey.
- We will study various cases that might occur during the course of the SN survey:
  - Galaxies at various redshifts.
  - Various SN models.
  - Various SN positions in the host galaxies.