An Unbroken View of the Milky Way

Continuous maps of faint emission lines at sub-parsec scales with the SDSS-V Local Volume Mapper

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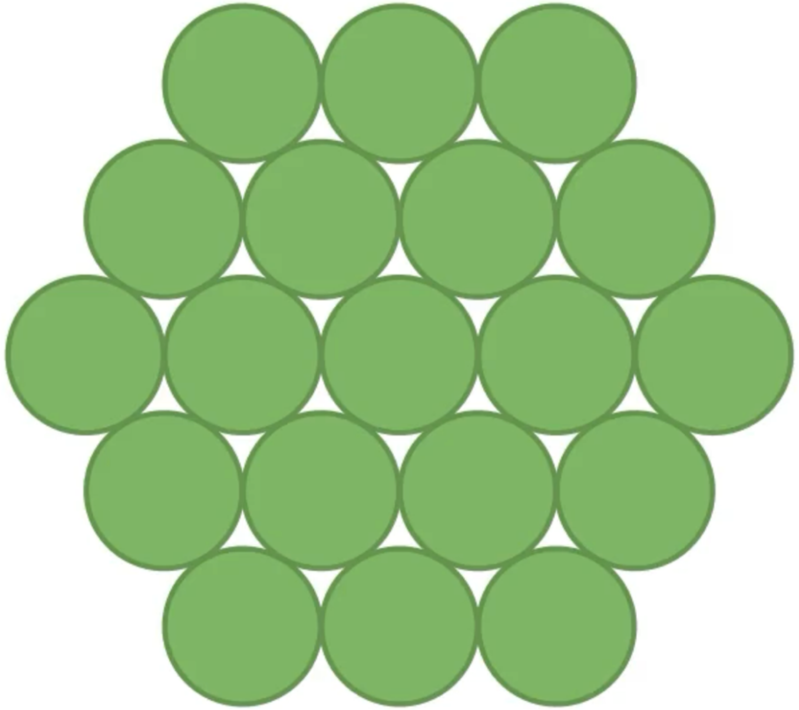
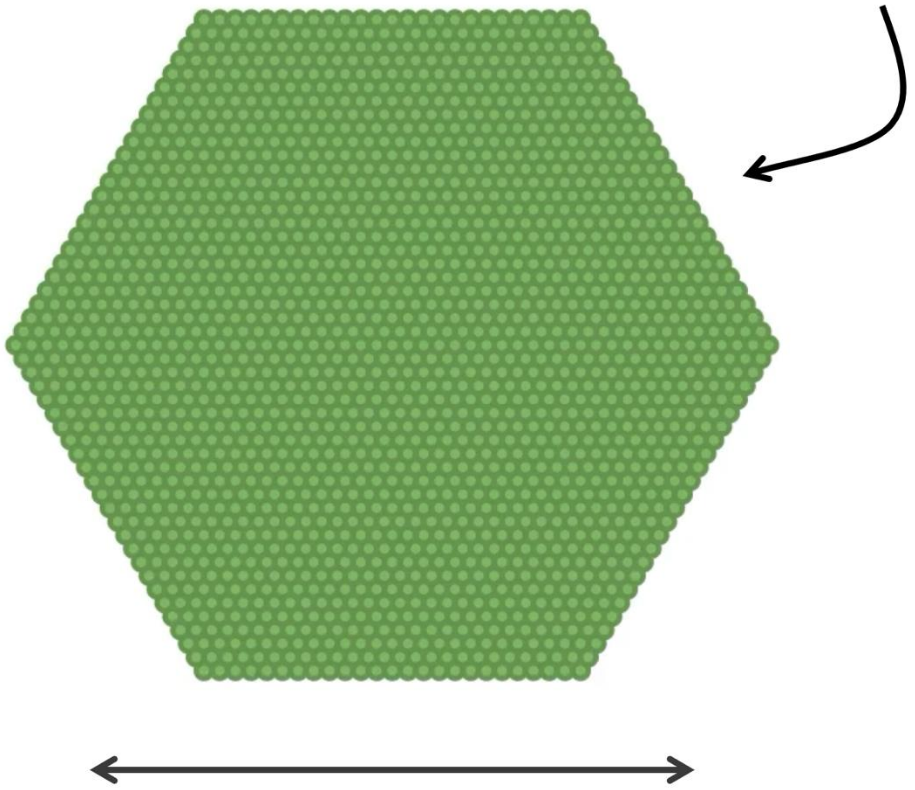
SDSS-V

Local Volume Mapper



- SDSS-V
- Optical + near-IR IFU survey
- Las Campanas, Chile

Full IFU



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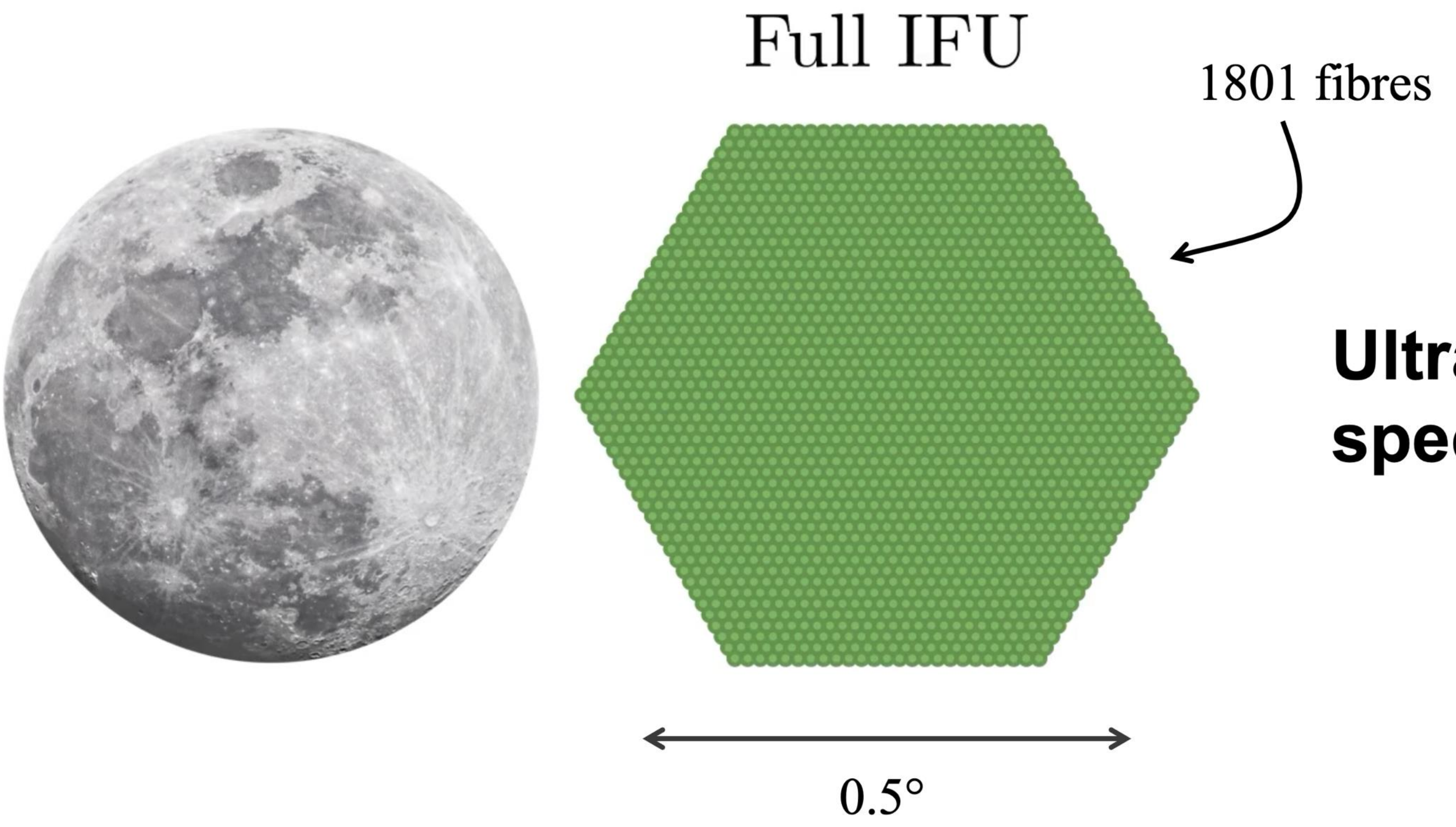
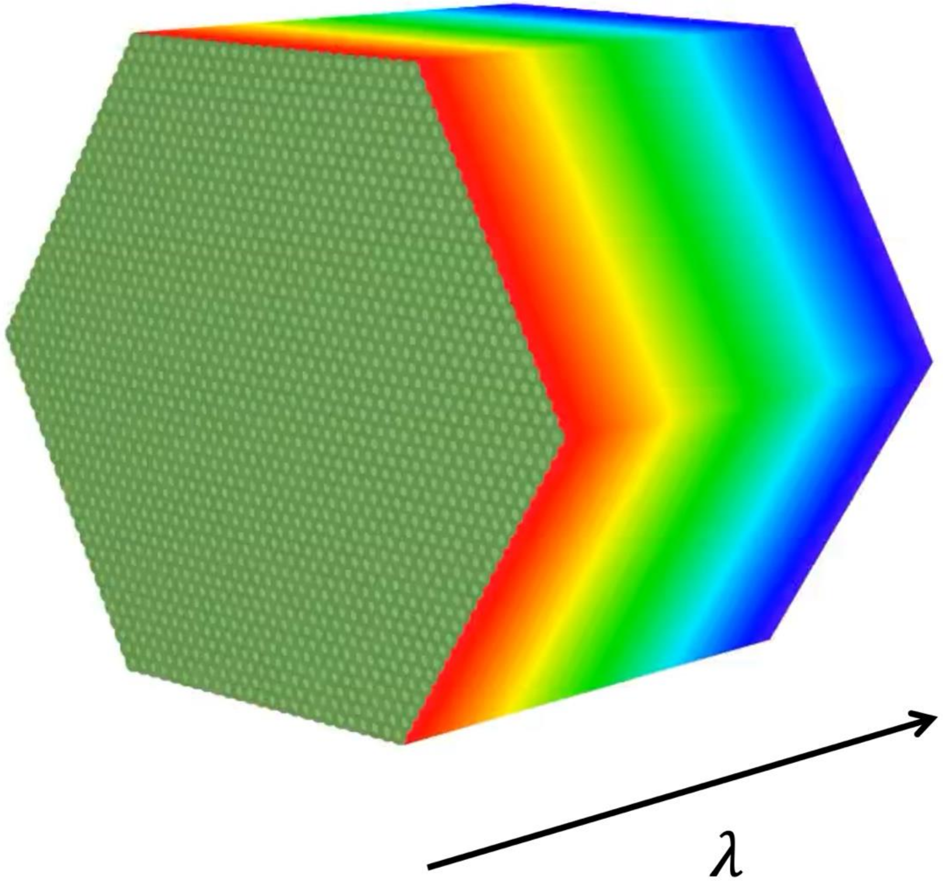


Ultra wide field spectroscopy

- $3600 - 9300$ Å

- $R \sim 4000$



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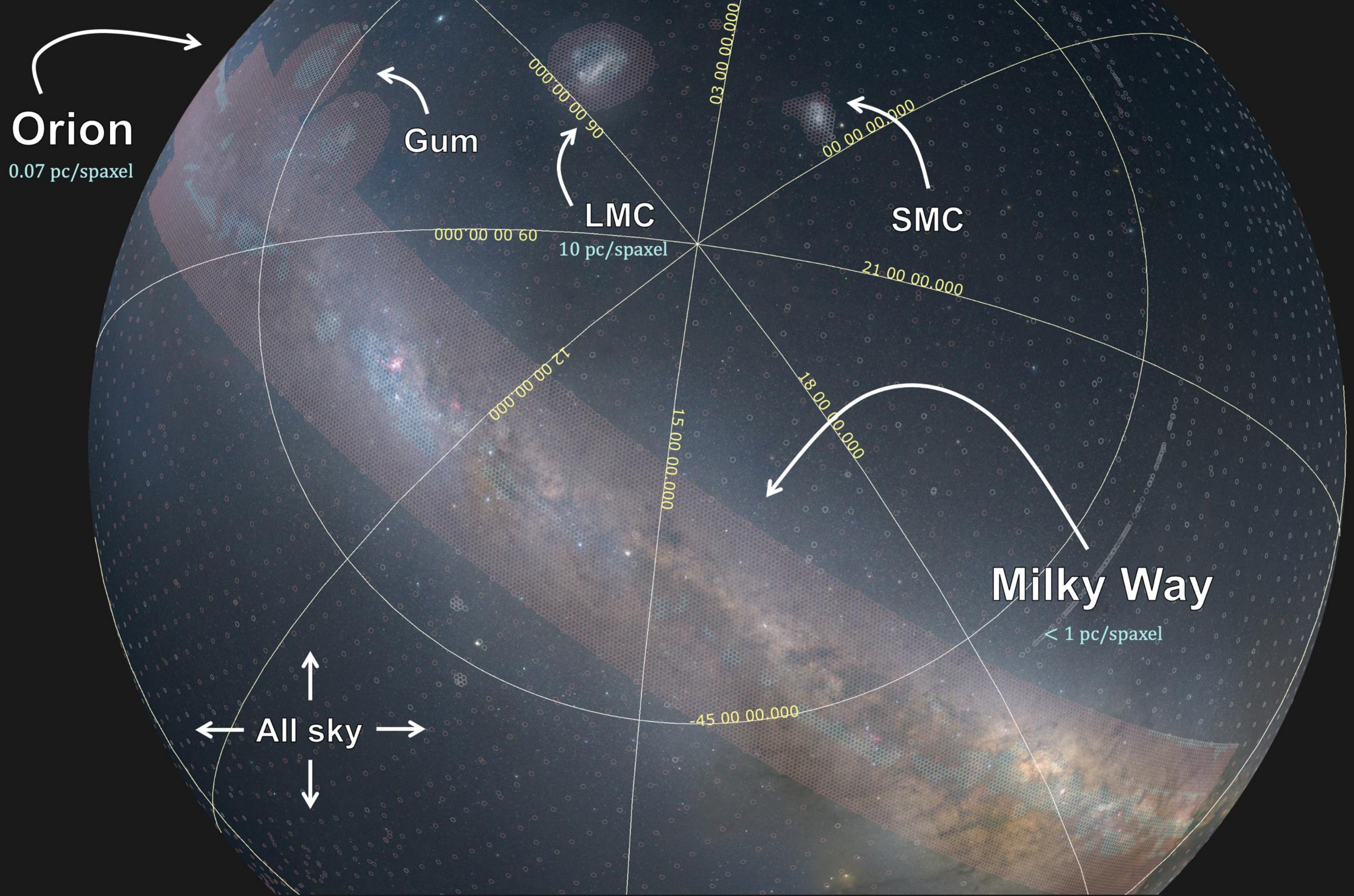


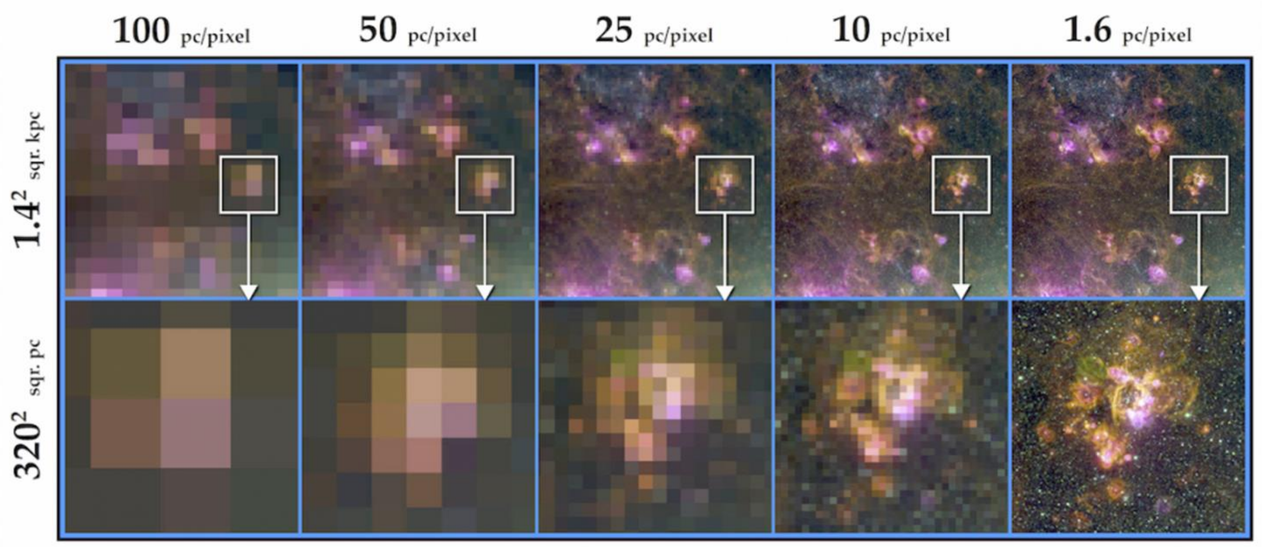
Orion
0.07 pc/spaxel
Gum
LMC
10 pc/spaxel
SMC
03 00 00.000
00 00 00.000
21 00 00.000
18 00 00.000
15 00 00.000
12 00 00.000
-45 00 00.000
Milky Way
< 1 pc/spaxel
All sky

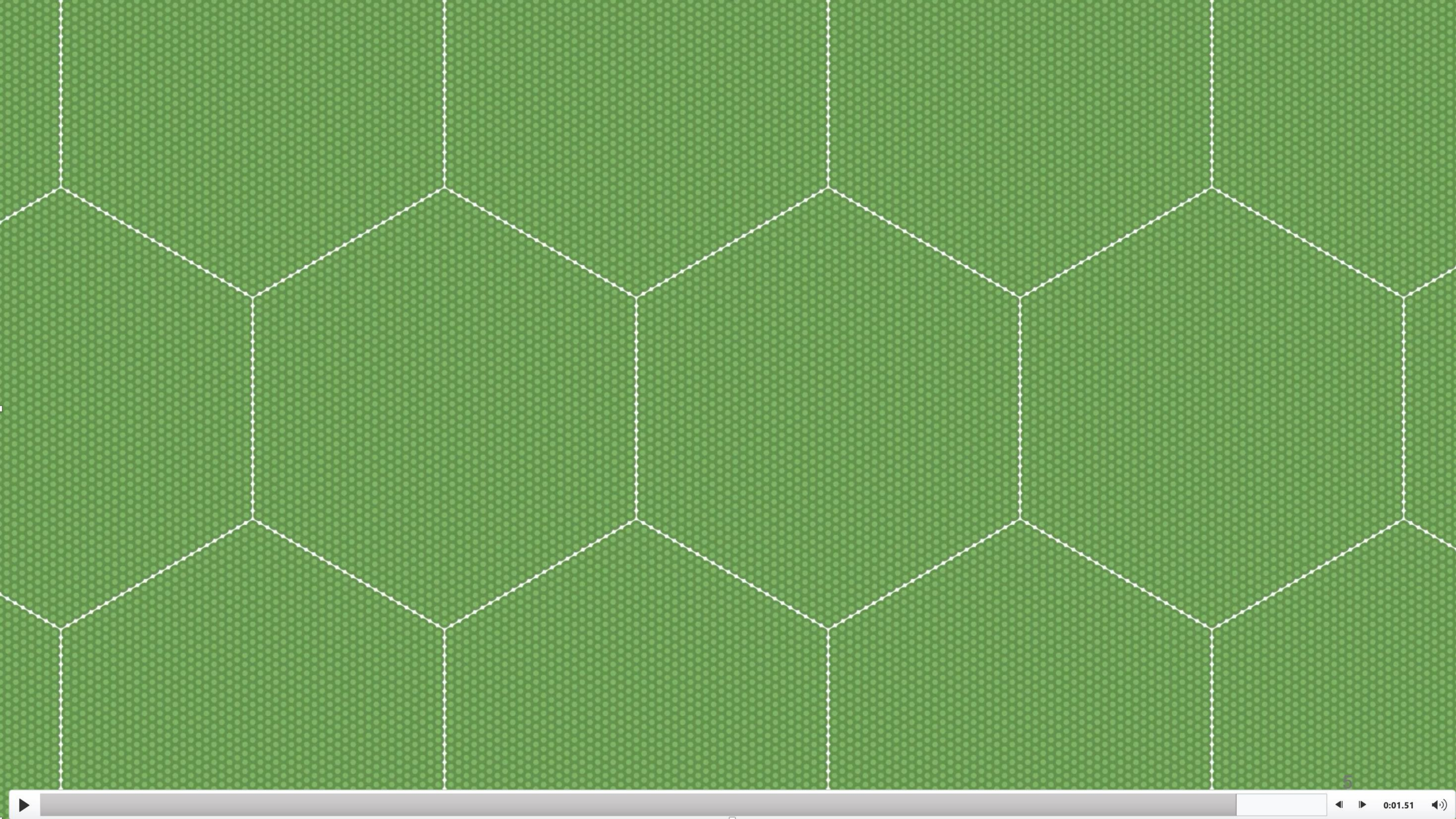
Why?

- How energy/momentum injected + transported though ISM
  - Stellar feedback
  - Connect small and large-scale evolution

- Emission lines
  - Gas density, temp, pressure, kinematics
  - **Weaker auroral and recombination lines**

- Abundance discrepancy problem

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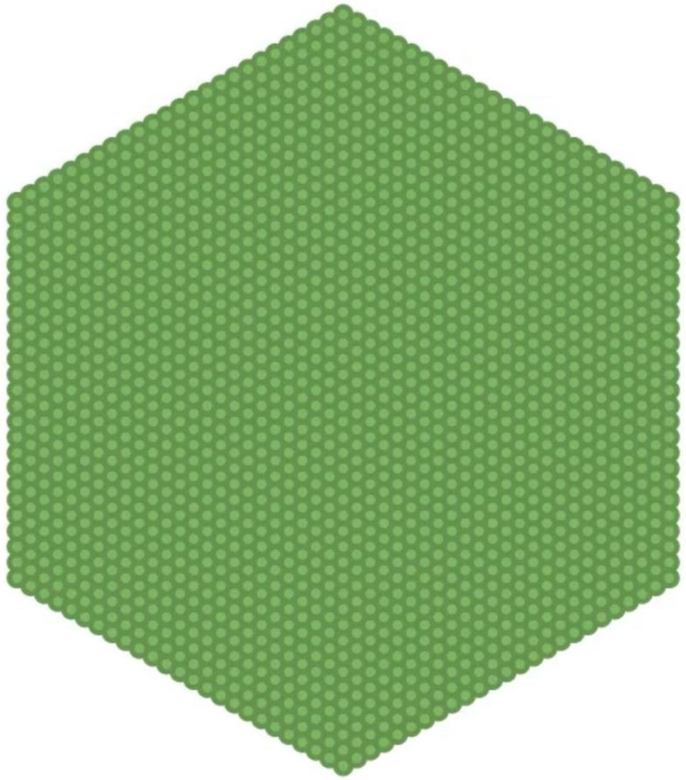
Spectra modelled independently



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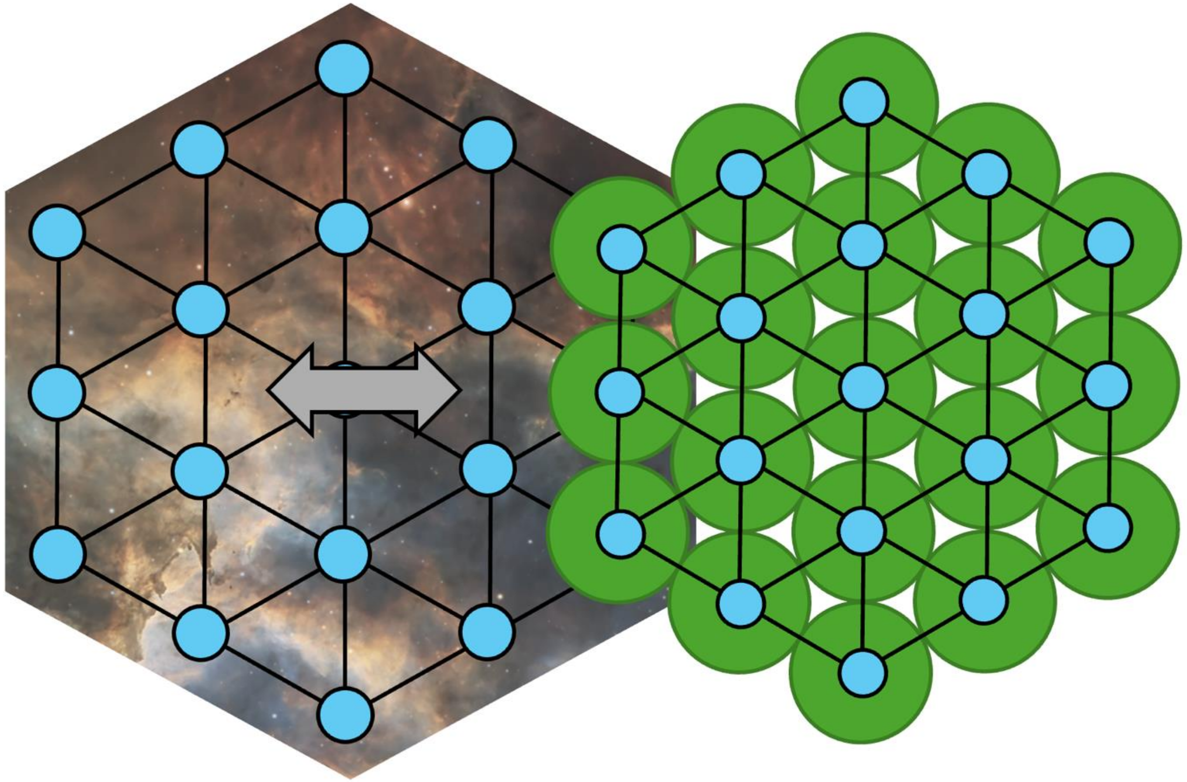
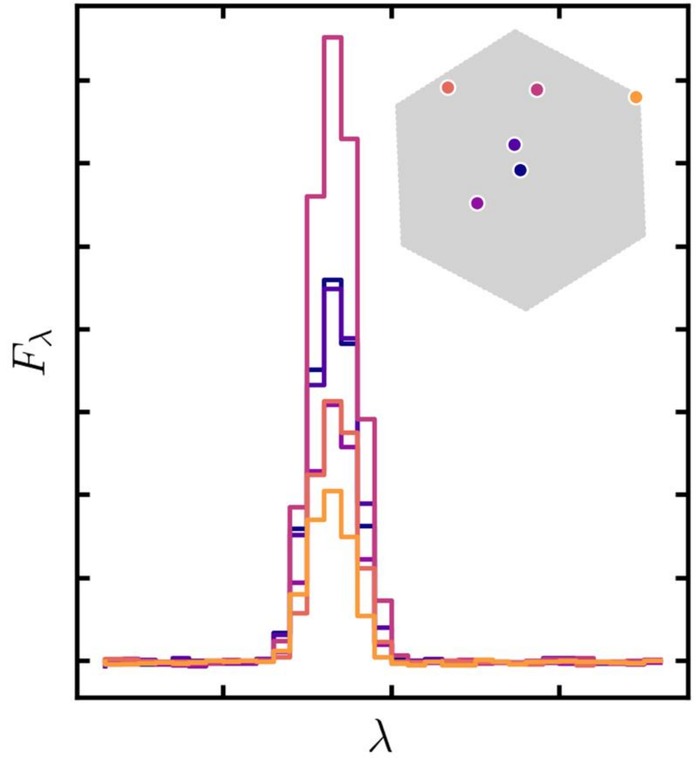


Nearby spaxels are more **similar**

Model spaxels **together**

Spectrospatial models



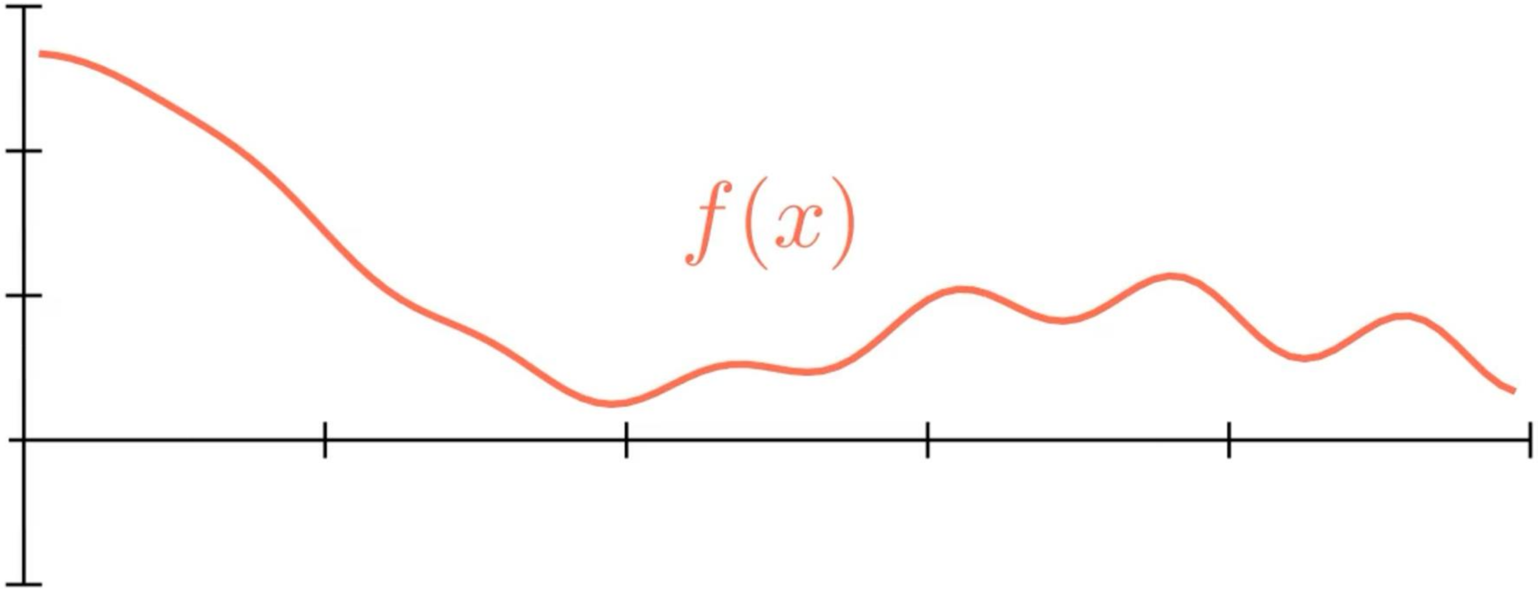
$$F_\lambda\left(\lambda_i, F_j, \mathrm{const}_j\right) = \overbrace{F_j \,\mathrm{Gaussian}\left(\lambda_i\right)}^{\text{emission line}} + \overbrace{\mathrm{const}_j}^{\text{continuum}} + \mathrm{noise}$$

Change to **function**

Fit for line flux in each spaxel

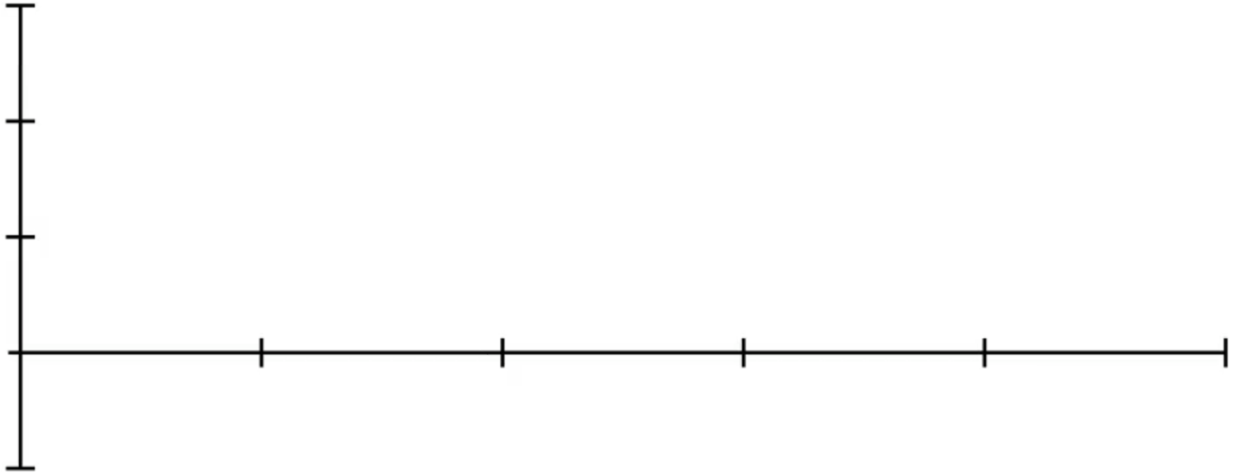
$$F_\lambda\left(\lambda_i, \underbrace{x_j, y_j}_{\text{spatial dependence}}, F, \mathrm{const}_j\right) = F(\underbrace{x_j, y_j}_{\text{spatial dependence}}) \,\mathrm{Gaussian}\left(\lambda_i\right) + \mathrm{const}_j + \mathrm{noise}$$

$F(x, y)$ gives line flux for any x, y


f(x)

$$\mathbf{y} \sim \mathcal{N}\left(f(\mathbf{x}), \mathbf{C}\right)$$

$$f(\mathbf{x}) \sim \mathcal{N}\left(\mathbf{0}, k(\mathbf{x}, \mathbf{x}')\right)$$



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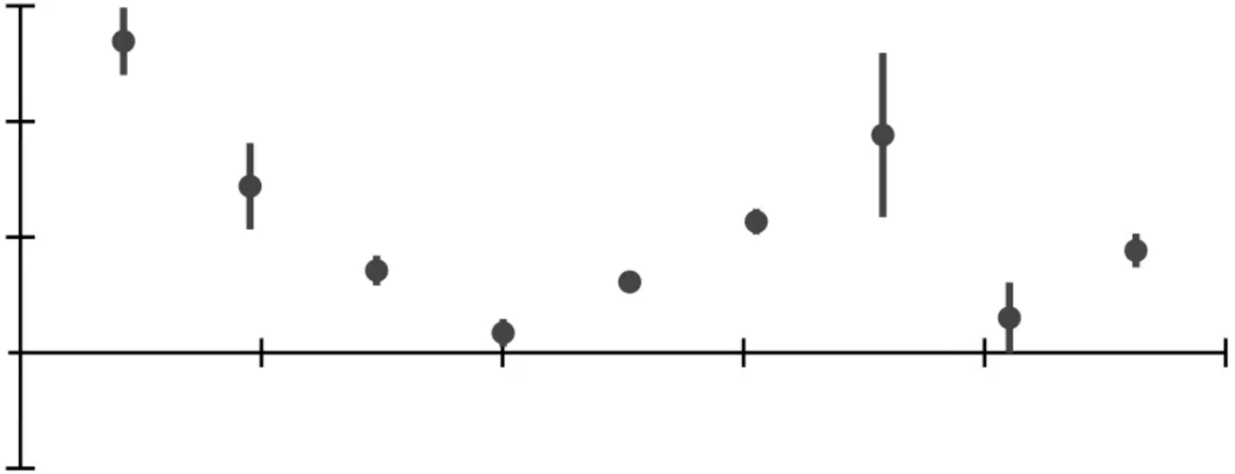
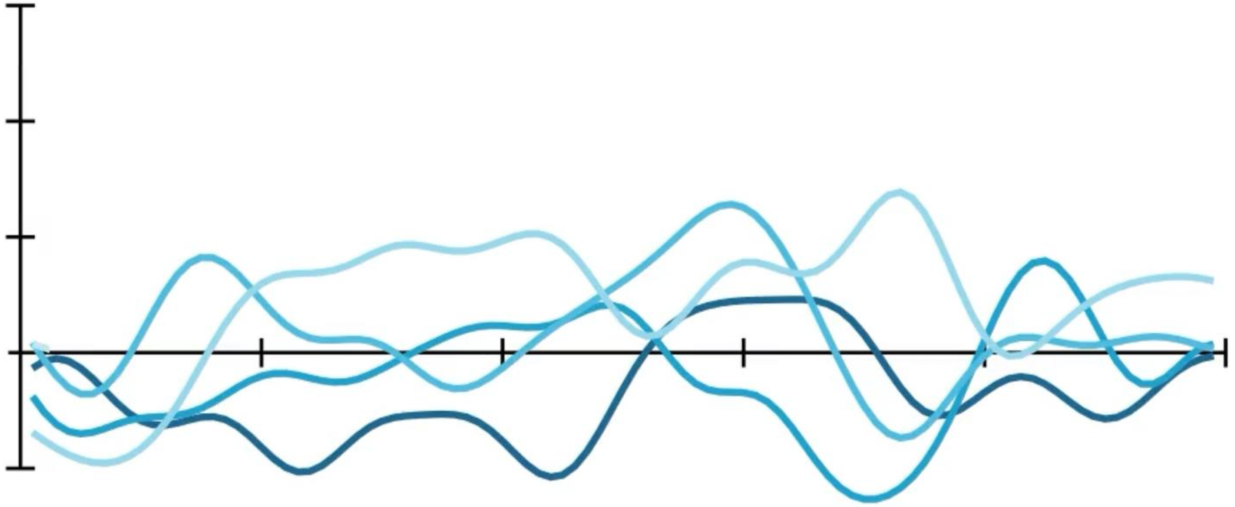


$$f(\mathbf{x}) \sim \mathcal{N}\left(\mathbf{0}, k(\mathbf{x}, \mathbf{x}')\right)$$

$$k(x_i, x_j) = \lambda^2 \exp\left(-s\,|x_i - x_j|^2\right)$$



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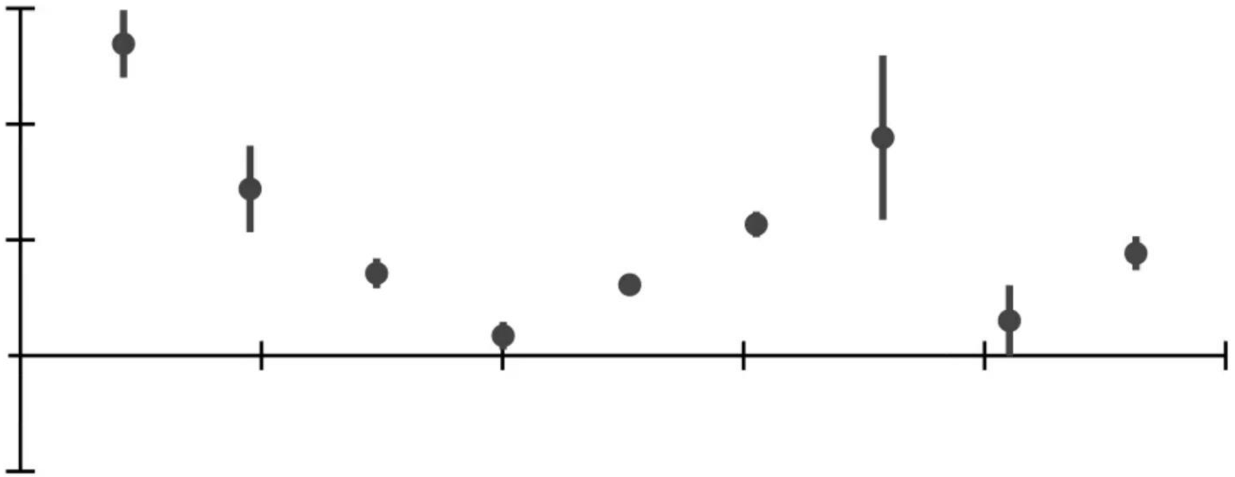

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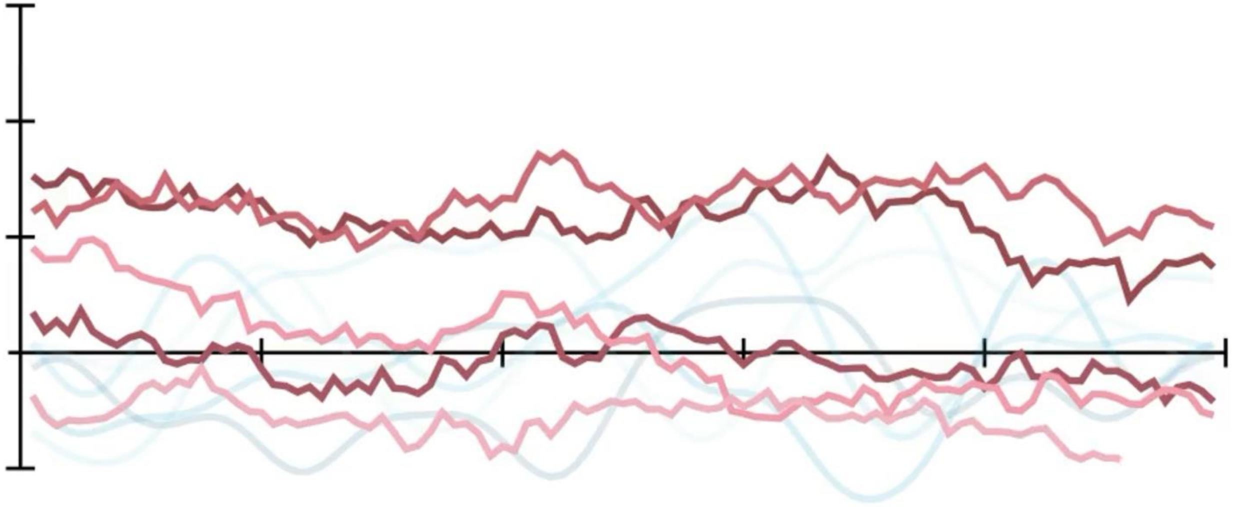

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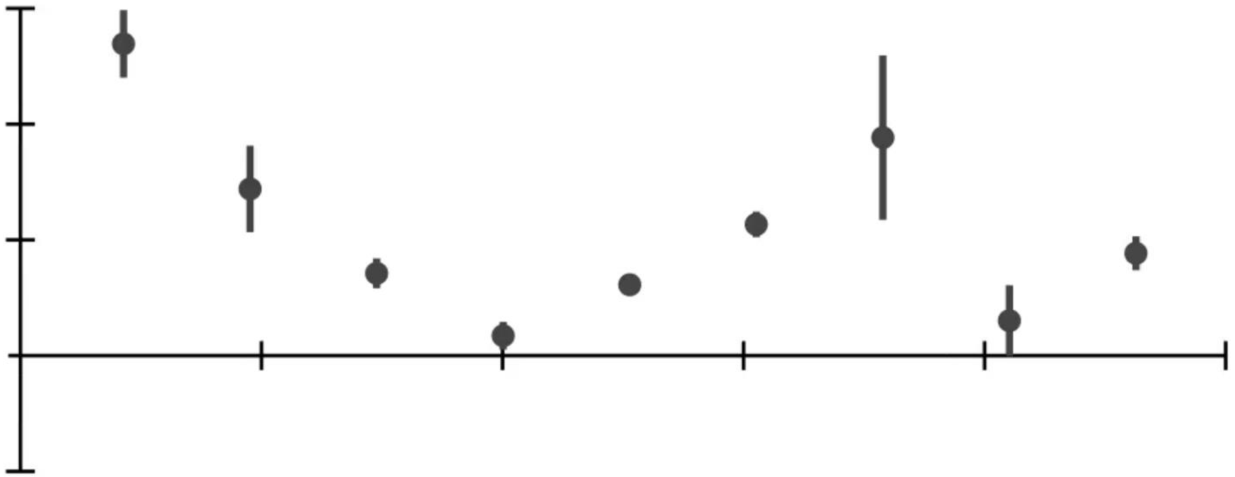

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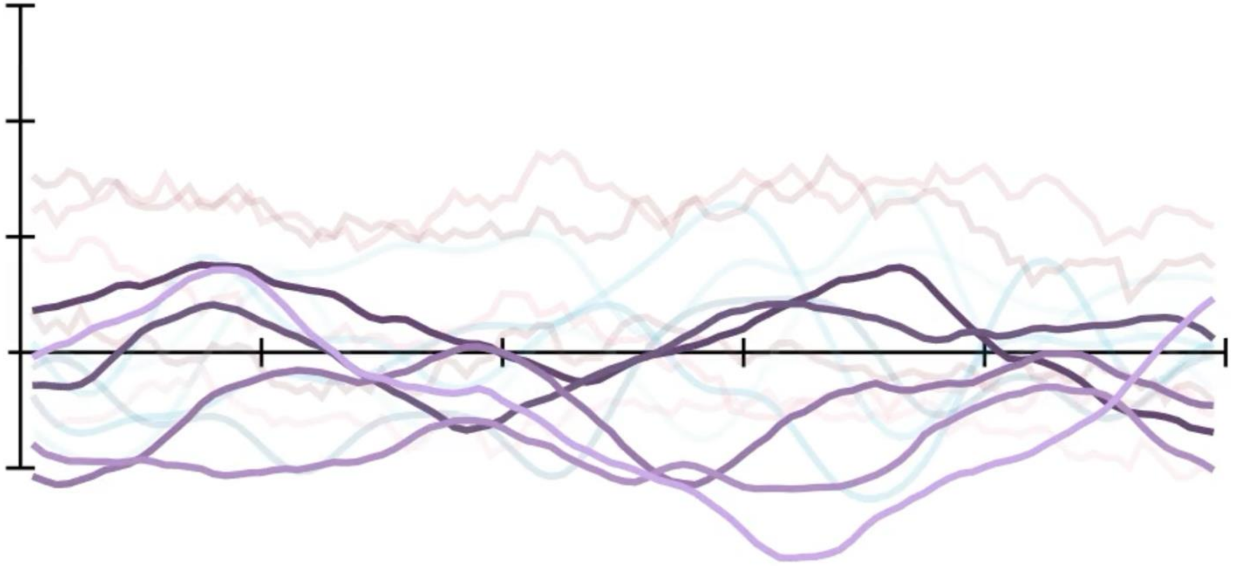

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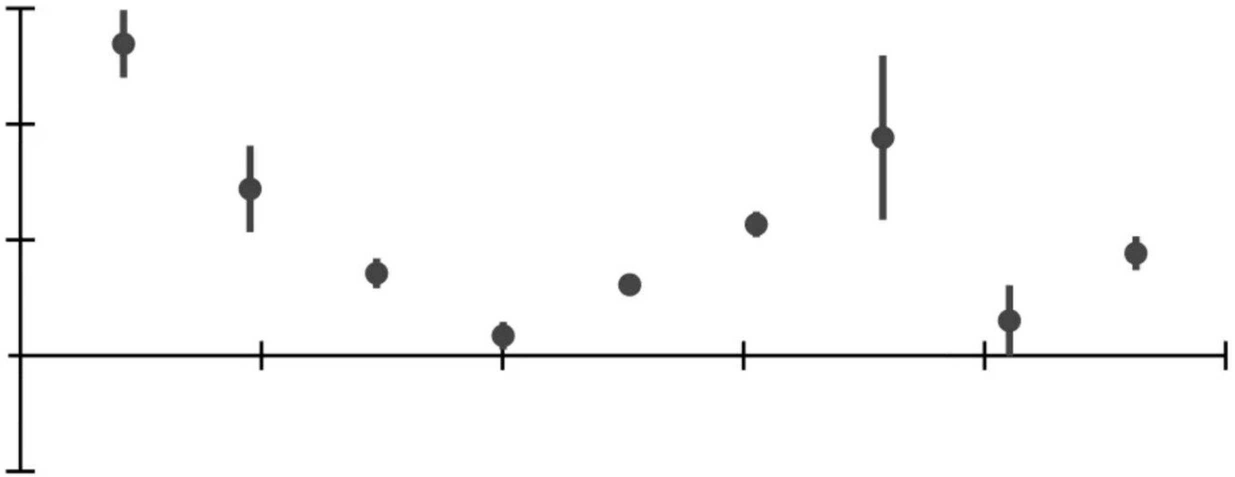
$$k(x_i, x_j) = \lambda^2 \left(1 + \frac{|x_i - x_j|}{s}\right) \exp\left(-\frac{|x_i - x_j|}{s}\right)$$

$$\mathbf{y} \sim \mathcal{N}\left(f(\mathbf{x}), \mathbf{C}\right)$$



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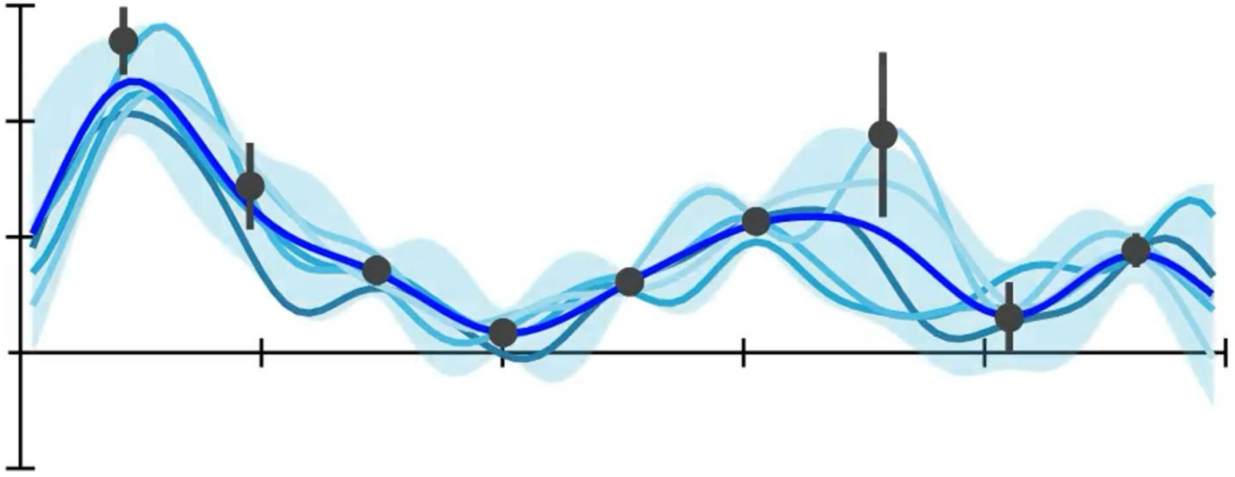

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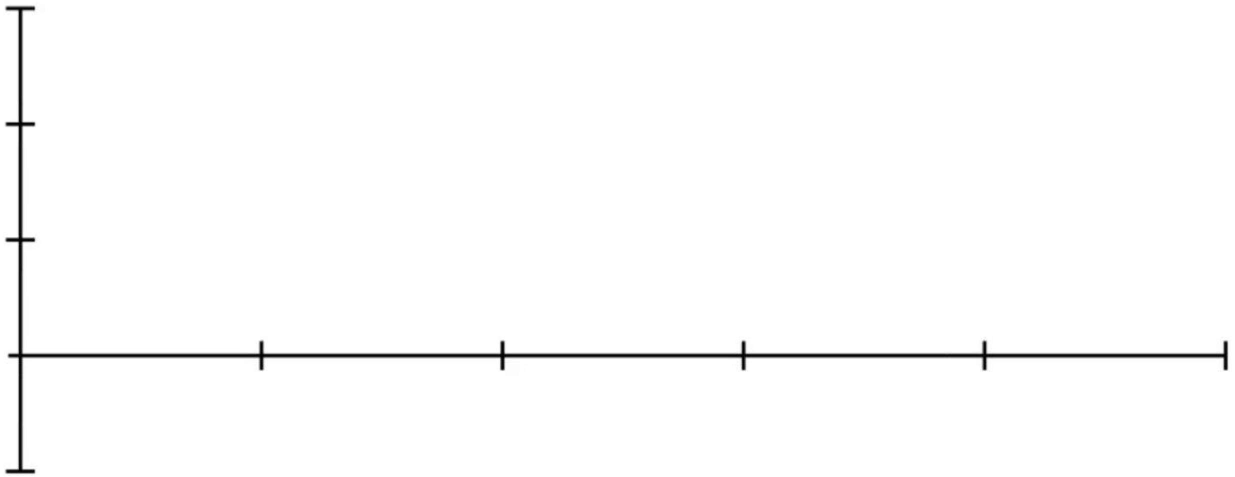
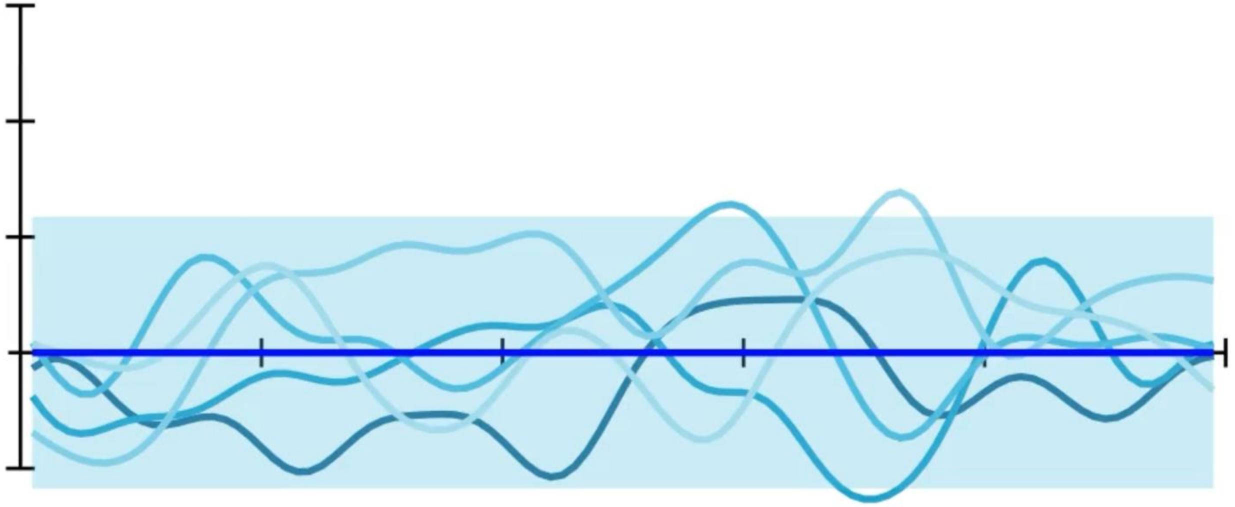
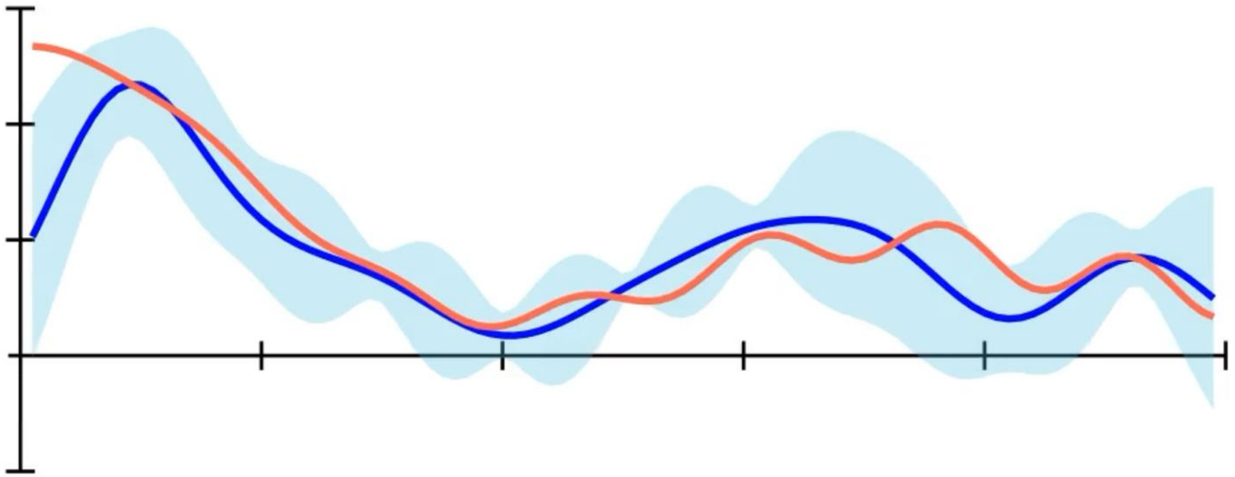


Prior

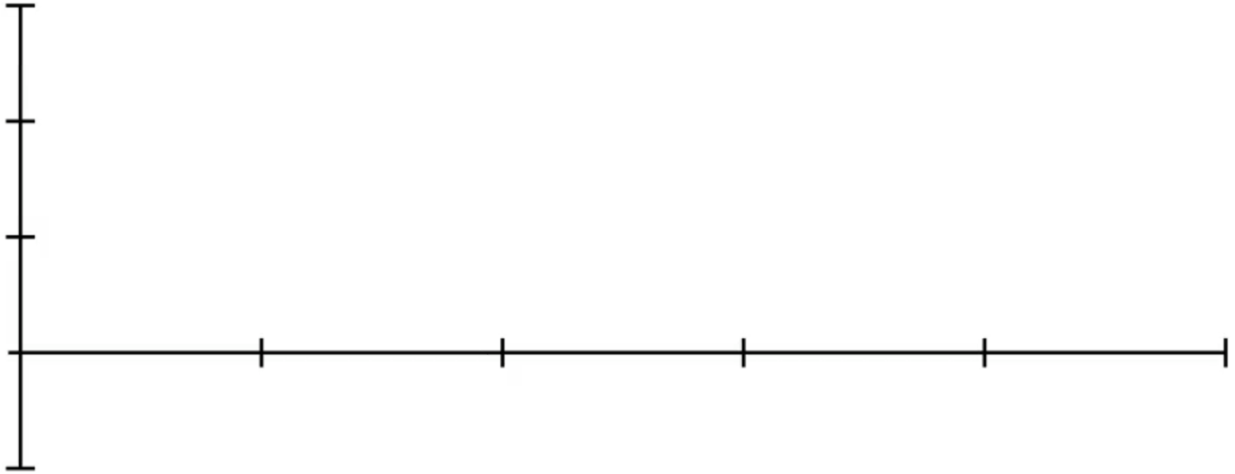


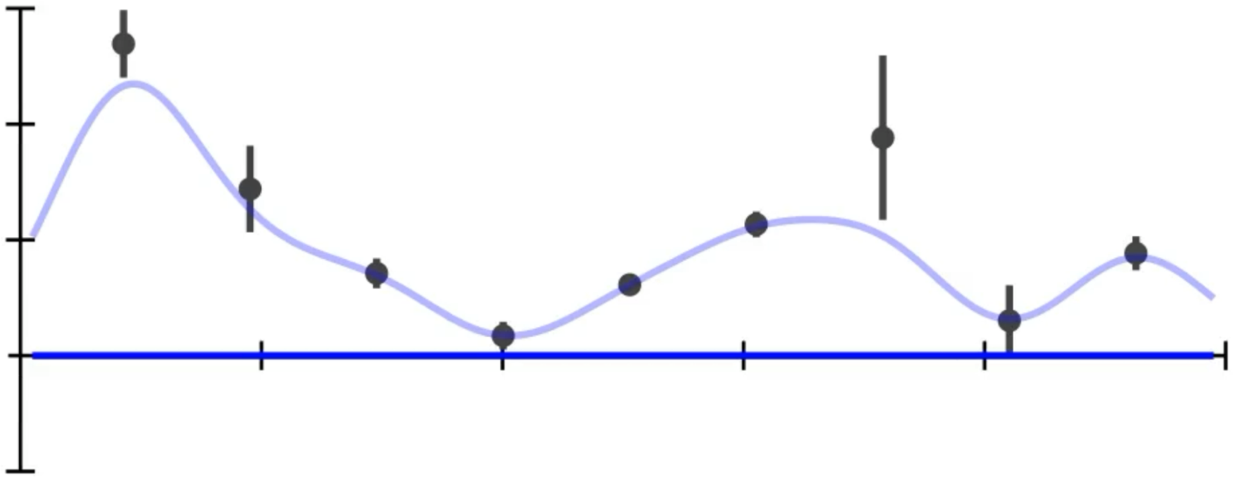
Data

Posterior



$$f(x_i) = \sum_{j=1}^{p} X_j \, e^{-\omega_j x_i}$$





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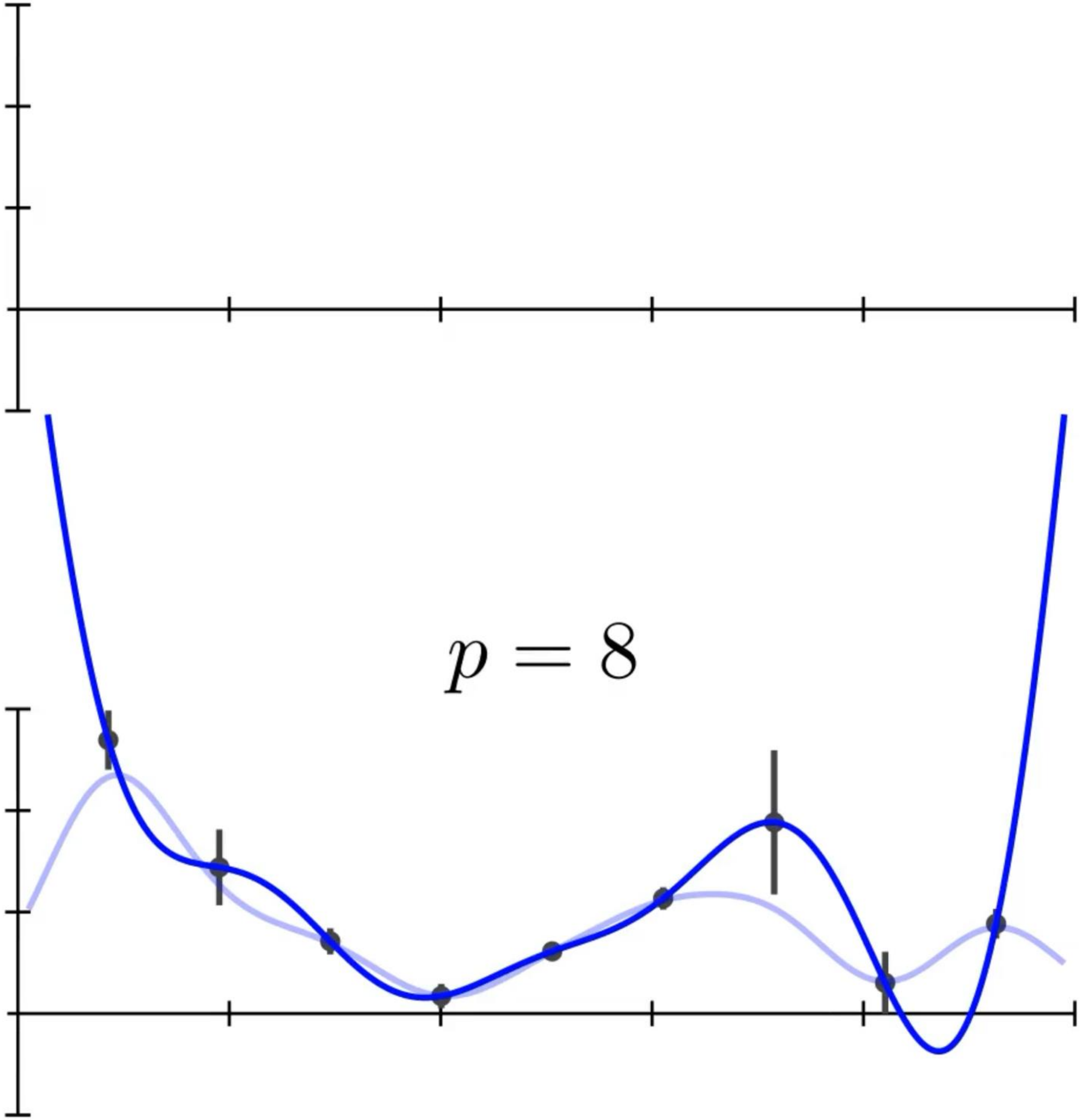
$$f(x_i) = \sum_{j=1}^{p} X_j \, e^{-\omega_j x_i}$$



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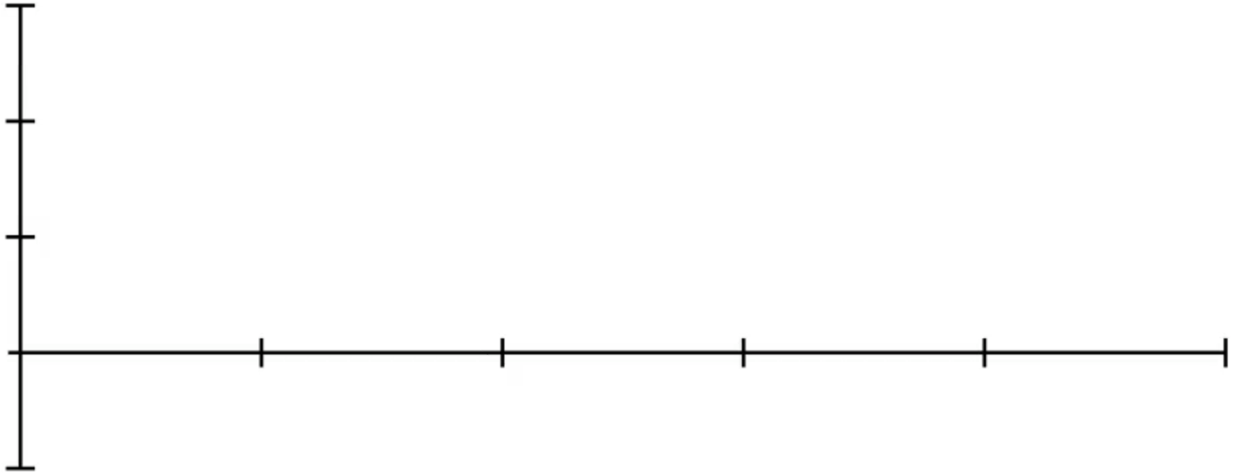
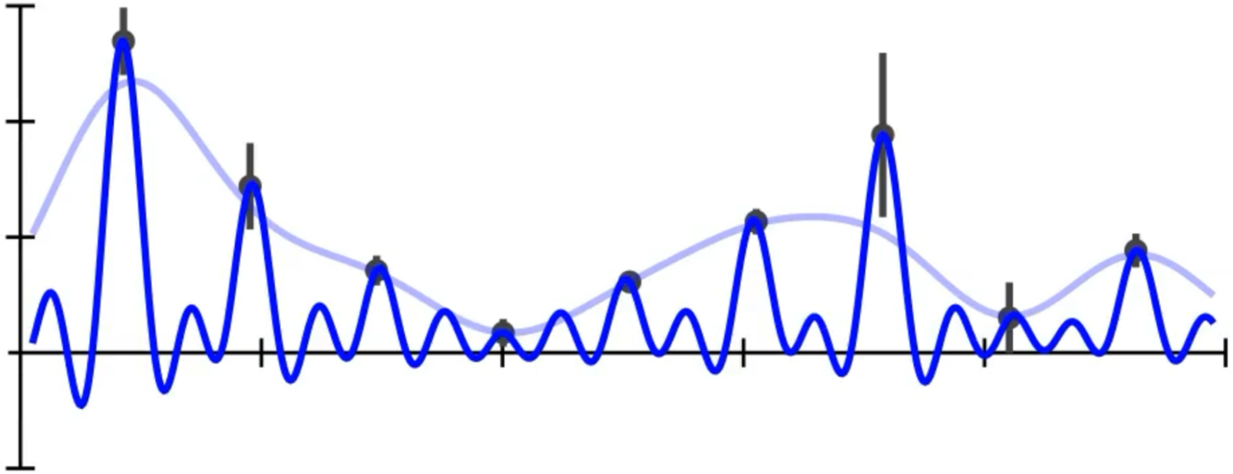


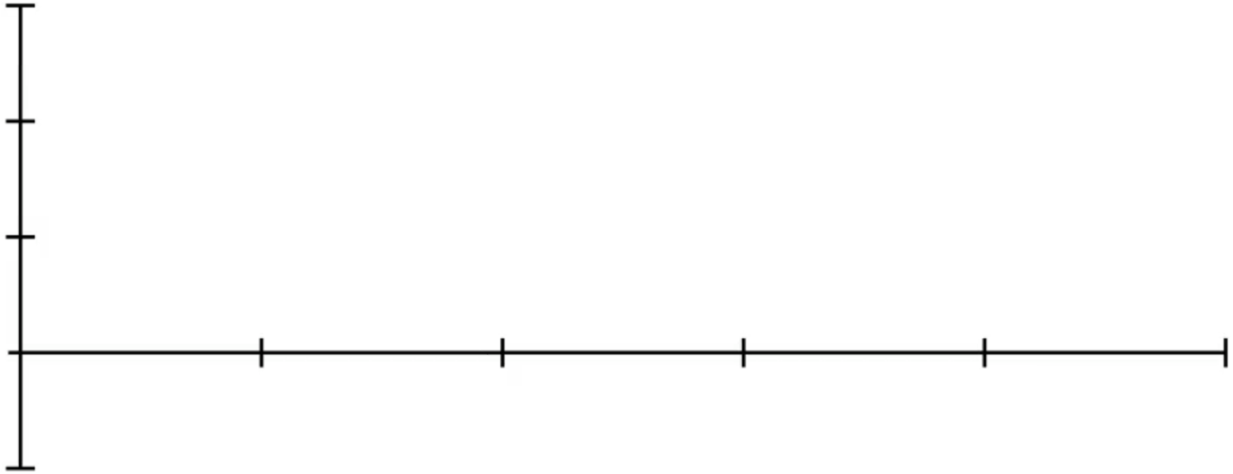
$p = 50$



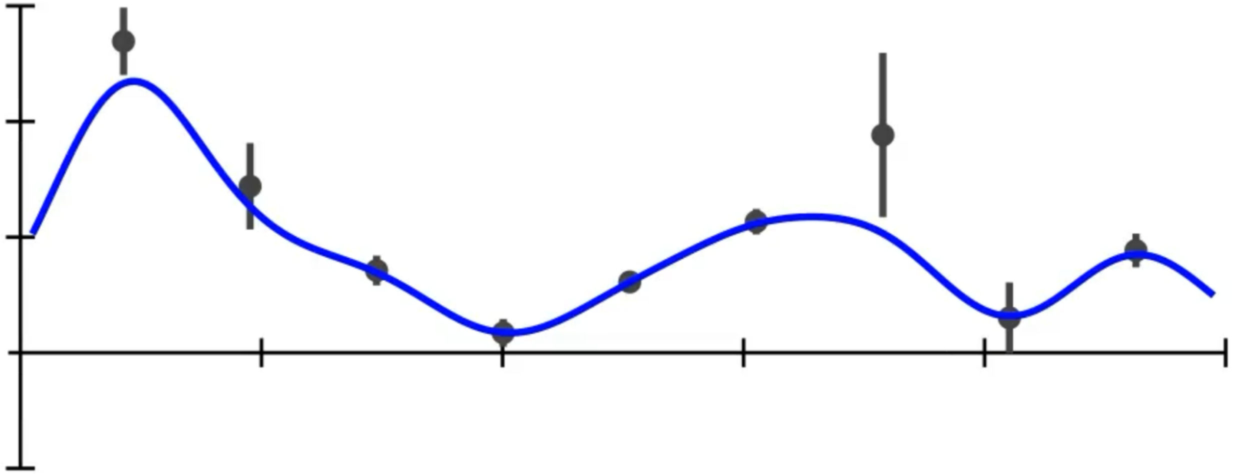
$$f(x_i) = \sum_{j=1}^{p} X_j \, e^{-\omega_j x_i}$$

$\cancel{O(n^3)}$

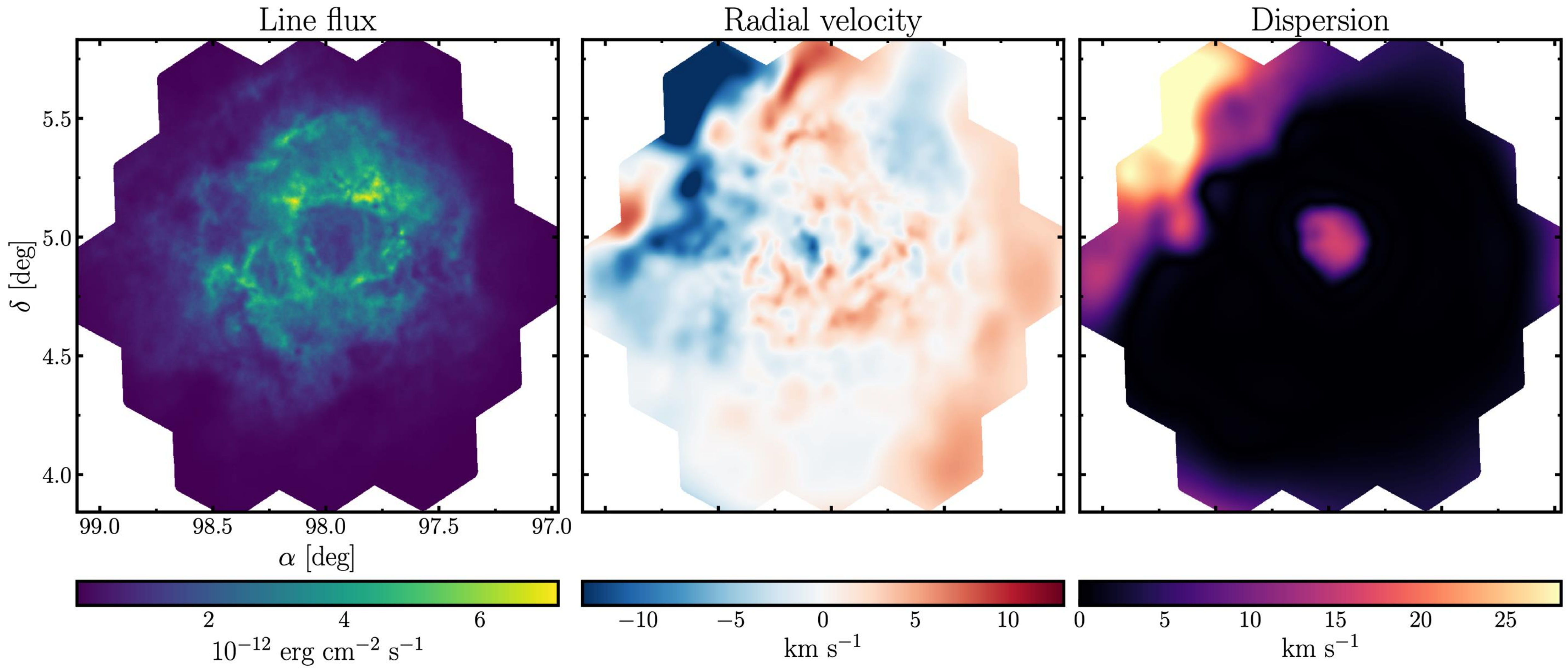
$O(n \log n)$



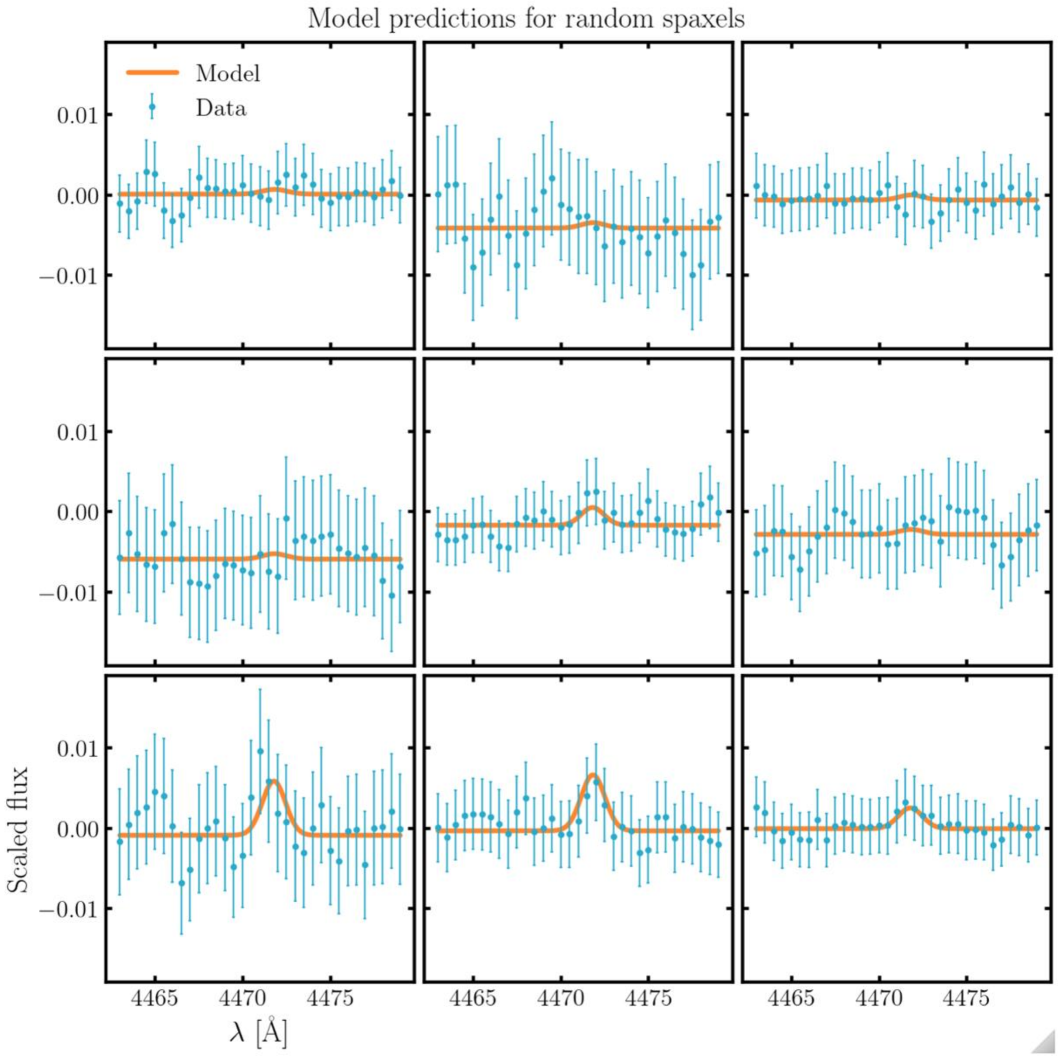
$$X_j \rightarrow \sqrt{\mathcal{F}[k]} X_j$$

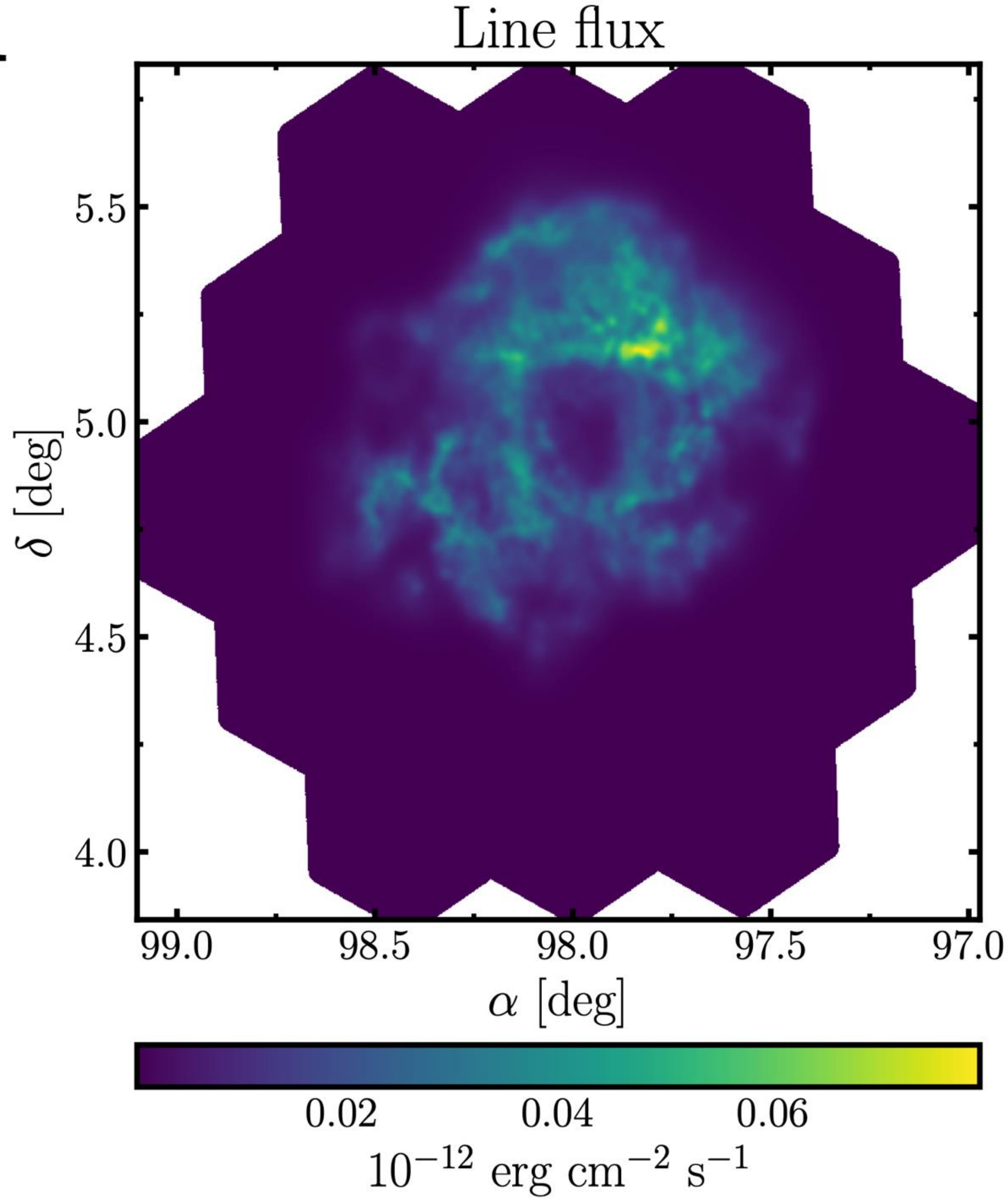


Rosette Nebula: Hα



Rosette Nebula: HeI 4471





Future

- Apply to other HII regions in LVM
- Combine dithers for super-resolution
- Couple strong lines with low S/N lines
- Beyond LVM

Spectrospatial Models for LVM & Beyond

Spatial info -> higher precision

Continuous predictions on sky

Recover weak lines

General + scalable framework