Astronomical Surveys: From Electrons to Science

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How To Analyze Astronomical Data
Inside the Sausage Machine
Example: Finding $z \sim 6$ Quasars
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With Xiaohui Fan and Michael Strauss and Željko Ivezić (and ... )
Example: Finding $z \sim 6$ Quasars

How does a photometric survey find Quasars?
Colour Selection of Quasars
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$z < 2.2$ quasars

$z > 3$ quasars
Colour Selection of Quasars

$z > 4.5$ quasars
Why isn’t this Easy?
Objects Are Blended
Objects Move
The semi-major axis v. (proper) inclination of a sample of known asteroids detected by SDSS
The PSF can be Complicated
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Two solutions:
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- Normalise the seeing to some canonical form and value (cf. A&L image subtraction)
  - Involves some measure of deconvolution (or loss of S/N)
  - Slower, more complex code
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• Normalise the seeing to some canonical form and value (cf. A&L image subtraction)
  – Involves some measure of deconvolution (or loss of S/N)
  – Slower, more complex code

• Estimate the seeing at the position of each object
  – Fast; a simple linear reconstruction at position of each object
  – The seeing is still variable across the frame
We chose the latter:

- KL decompose the bright stars in the frame, giving a number of basis functions (typically 3 or 4):
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\[
P_{ij} = \sum_{\alpha=0}^{n-1} A^{(\alpha)} K_{ij}^{(\alpha)}
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$$P_{ij} = \sum_{\alpha=0}^{n-1} A^{(\alpha)} K_{ij}^{(\alpha)}$$

- Write the $A^{(\alpha)}$ as low-order polynomials in $x, y$:

$$P_{ij}(x, y) = \sum_{\alpha=0}^{n-1} \sum_{r=0}^{n_r-1} \sum_{s=0}^{n_s-1} a_j^{(\alpha)} x^r y^s K_{ij}^{(\alpha)}$$
If you combine the last three points:

- blending
- moving
- variable seeing

it is not obvious how to build a catalogue out of a set of observations.
Not all Objects are Point Sources

All Objects
Not all Objects are Point Sources

Stars and Galaxies
Not all Point Sources are Point Sources

Stars and Galaxies and Cosmic Rays
Not all Point Sources are Point Sources

Stars and Galaxies and Cosmic Rays (cumulative)
High-z Quasars

$z > 4.5$ quasars
High-z Quasars are not very Bright
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The small dots are $10^5$ stars (from $\sim 10\text{deg}^2$ of sky)
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The small dots are $10^5$ stars (from $\sim 10\,\text{deg}^2$ of sky)
The quasars (and L/T stars) are from $\sim 2000\,\text{deg}^2$
All that Glistens isn't Gold
All that Glistens isn’t Gold
All that Glistens isn’t Gold
Is Anything Left?
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Recommendation: Advertise a tenured faculty position
The End