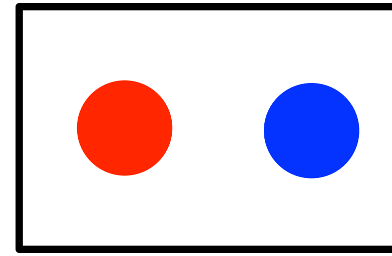
Forced Photometry

Forced photometry versus cross-matching surveys

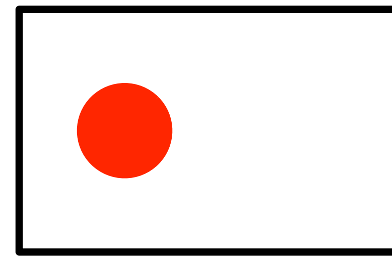
- Cross-matching sources between different imaging surveys, and assuming that you're looking at the same source in both surveys, inevitably discards information
- To understand why we have to think about how a "source" (a star, galaxy, quasar etc.) ends up being recorded in a sky survey catalog
- To catalog a source, sky surveys want to be certain that they've actually detected it, so they set some threshold of significance above the general sky background
  - to see why, study an image in the *SDSS Navigator Tool* and think about whether faint sources are *real*
- Often, this threshold is set at a signal-to-noise ratio of 5, which I will refer to as a "5σ detection"

Forced photometry versus cross-matching surveys

- Consider the "true" image of a small part of the sky to the right, in which there is a very red galaxy and a quite blue galaxy

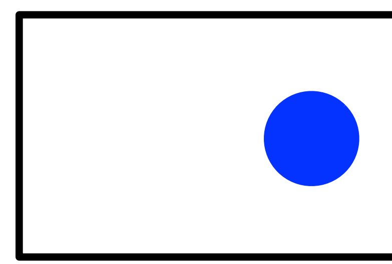


- In an infrared survey of the sky, the red source is detected at 6σ, but the blue source is only detected at 4σ



  - So, a (> 5σ) catalog of sources from the infrared survey just "sees" the red source

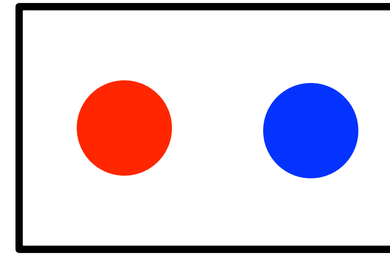
- In an optical survey of the sky, the blue source is detected at 6σ, but the red source is only detected at 4σ



  - So, a (> 5σ) catalog of sources from the optical survey just "sees" the blue source

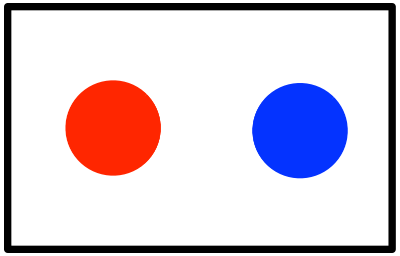
Forced photometry versus cross-matching surveys

- In the "true" image the two different galaxies are very close together, separated by only, say 1"



- So, when the two surveys are cross-matched, the red and the blue galaxy are likely to be confused as a single source
- Before large surveys of the sky, this wasn't a problem, as people would look at the images and determine which galaxy was which by visual inspection
- But, in sky surveys that contain hundreds-of-millions of astronomical sources, this confusion between sources can become a problem

Forced photometry versus cross-matching surveys



- The solution is not to store astronomical surveys at the 5σ source level, but instead to store the raw images
  - the actual information that telescopes collect, which are the pixels of the survey
- A more correct approach to finding sources in surveys that circumvents issues with cross-matching would be:
  - find the positions of all sources that are detected in any survey or in any combination of surveys
  - Sink an aperture at that position in *all* sky surveys
  - Measure the flux at that position in *all* sky surveys using the native images of the survey

Forced photometry versus cross-matching surveys

- This process is sometimes called *forced photometry*
  - "forced" because a detection of a source (say $>5\sigma$) in one survey is used to measure fluxes of that source in other surveys, even if *the source isn't detected in those other surveys* (say $<5\sigma$)
- This is an example of how better use of information can be used to improve our understanding of data
  - The information that a source exists (because it is detected in one survey or combination of surveys) is used to infer that it must exist in other surveys
- Forced photometry of a survey can be complex. We will study its results using existing forced photometry of WISE images at SDSS source positions

Python tasks

1. The DR15 “stargal-primary” sweeps at */astro/astr8020/dr15/eboss/sweeps/dr13_final/301/** match files “wise-stargal-primary” files at the same location, which are WISE files force-photometered at primary SDSS positions (by Lang et al. 2014; see the syllabus link)
   - read in a DR15 sweep file and a matching WISE file and check they contain the same number of objects
2. Find the closest SDSS object in the sweep files (of type “star”) to the position $(\alpha,\delta) = (143.209^{\circ}, 36.701^{\circ})$ and record that object’s SDSS *PSFFLUX* measurements
   - use my *sdss_sweep_data_index.py* code from Monday to determine which sweep files contain objects near the position $(\alpha,\delta) = (143.209^{\circ}, 36.701^{\circ})$

Python tasks

3. Find the matching WISE object and record the *W1* and *W2* flux measurements for this object
   - The WISE and sweep files match row-by-row
   - Object 99 in the stargal-primary sweep file of interest corresponds to object 99 in the matching WISE file

4. Repeat *2.* and *3.* for $(\alpha,\delta) = (199.783^{o}, 43.8613^{o})$...but keep your existing work for $(\alpha,\delta) = (143.209^{o}, 36.701^{o})$
   - plot the 7 fluxes (5 SDSS and 2 WISE) for both objects as a function of wavelength. *PSFLUX* corresponds to *ugriz* at 3543, 4770, 6231, 7625 and 9134 Å, *W1* and *W2* are at 3.4 and 4.6 μm.
   - The (α,δ) represent two different sources. Which is bright in the optical? Which is bright in the IR?