Max-Planck-Institut für Astronomie Heidelberg · Max Planck Institute for Astronomy Heidelberg

UNIVERSITÉ DE STRASBOURG

Observatoire astronomique de Strasbourg

Automated search for dwarf galaxies with latest Pan-STARRS data: Boötes I

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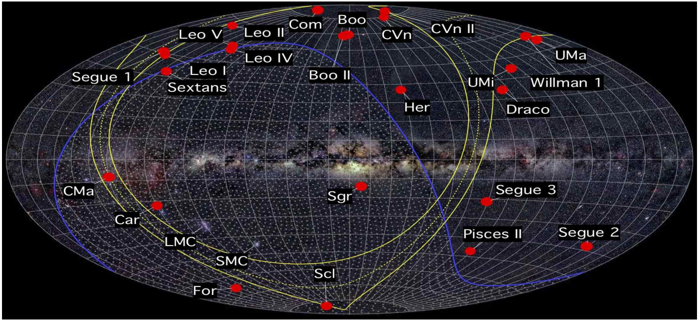
Presentation Overview

- Introduction
- Background
- Procedure
- Results
- Future Work and Improvements
- Summary and Conclusion

Introduction: Boötes I

- Overview of work
- Set up code and mathematical framework for automated search of dwarf galaxies
- Use Boötes I dwarf galaxy
  → l=358.1 and b=69.6



Maths (1)

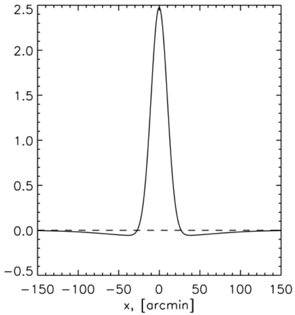
- Follow Koposov et al. (2008) for dwarf galaxy detection
- Aim? $\rightarrow$ Identify excess number of stars $\Rightarrow$ satellite galaxy
- How? $\rightarrow$ Convolution of objects' spatial distribution with a filter or kernel
- Need differential image map $\Rightarrow$ Identify the overdensities
  $\rightarrow$ Differential image map is difference of two convolutions, with different σ

Maths (2)

- Differential image map: difference between local density/signal (σ_1) and local background/noise (σ_2)

  $\rightarrow \sigma_1$ chosen in function of size of the targeted dwarf galaxy (code must be run for several values to get the ideal σ)

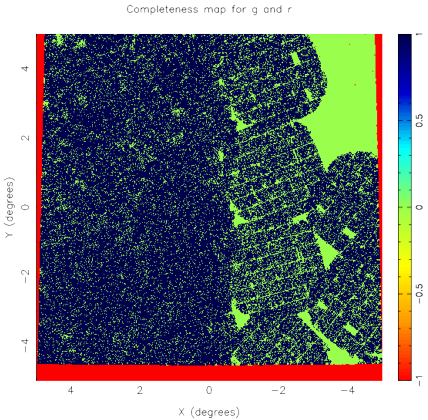
  $\rightarrow \sigma_2$ must be suitably large ($10\sigma_1$) to see the background effects



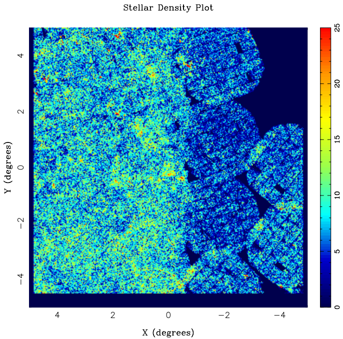
Additional effects to consider

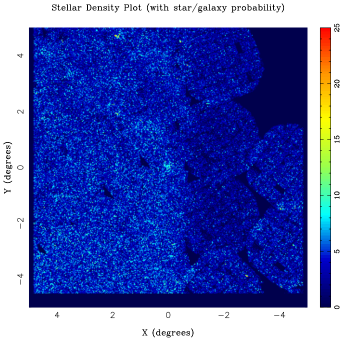
- Distinction between stars and galaxies?
  → Use N. Martin's star-galaxy separator (see talk)
  → Each object is assigned a probability ranging between 1 and 0.

- PS1: lots of holes
  → Take this spatial completeness into account



Can see the effects of including the star/galaxy probability





Background Summary

For the mathematics enthusiasts, this leads to the following expression to be evaluated:

$$n_{excess}(l,b) = \frac{\sum_{i=1}^{N_{*nearby}} w_{+}(l-l_i, b-b_i) * p_{*,i}}{\int_{l'}\int_{b'} c_{tot}(l',b') w_{+} dl' db'} + \frac{\sum_{i=1}^{N_{*nearby}} w_{-}(l-l_i, b-b_i) * p_{*,i}}{\int_{l'}\int_{b'} c_{tot}(l',b') w_{-} dl' db'}$$

or:

$$n_{excess} = \frac{\text{convolution positive gaussian}}{\text{normalisation factor}} - \frac{\text{convolution negative gaussian}}{\text{normalisation factor}}$$

where:

w_{+} and w_{-}: kernels (Gaussians) with σ_1 and σ_2 respectively

l and b: galactic longitude and latitude

c_{tot}: spatial completeness

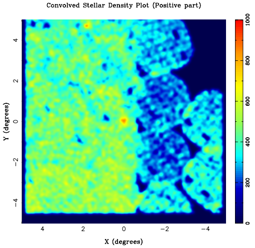
$p_{*,i}$: star/galaxy probability

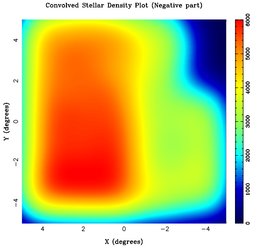
Colour Criteria

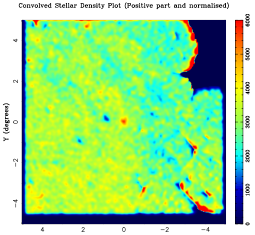
- Impose some colour criteria (Koposov et al. 2008)
  $\rightarrow g - r < 1.2$, $g < 23$ and $r < 22.5$
- Minimise code running time:
  $\rightarrow$ Calculate convolution with contribution of stars within 3σ
- Use 2 arcmin pixels
- For the completeness normalisation, use 0.5 arcmin pixels (so 16 of these correspond to 1 pixel in the convolution)
  $\rightarrow$ Again only consider the contribution of pixels within 3σ

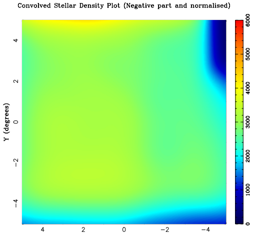
Different parts of the excess density expression

$$n_{excess} = \frac{\text{convolution positive gaussian}}{\text{normalisation factor}} - \frac{\text{convolution negative gaussian}}{\text{normalisation factor}}$$



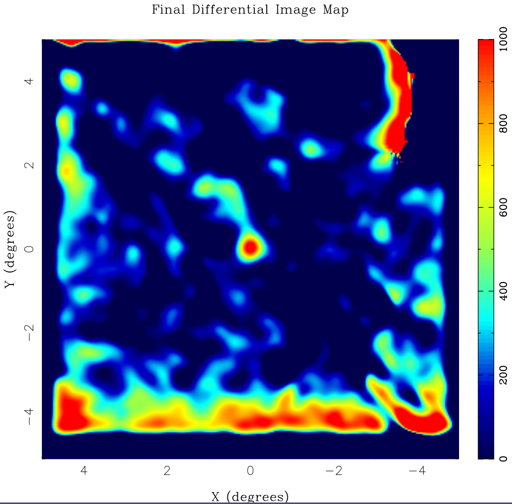






Final Differential Image Map

Putting the images of the two previous slides together gives:



Improvements

Things that weren't taken into account (but which should be):

- **Dust**
  $\rightarrow$ This influences the colour cut and will eliminate and add objects.
- **Signal to Noise**
  $\rightarrow$ Know Boötes I is centred at (0, 0), because set up that way
  $\rightarrow$ There could be other 'blobs' which you are inclined to think are satellites
  $\rightarrow$ Need to make S/N map $\Rightarrow$ Determine significance of over densities

Future Work

Future plans include:

- Incorporating elements from the previous slide
- Running the code on the entire sky
  → See how easily recover SDSS satellites in PS1
  → Run code on southern hemisphere
  → See if find anything new
  → Run code for whole stacked data and compare to current data
  → Based on time taken to run code for 10 $arcmin^2$, estimate all of PS1 should take one week

Summary and Conclusion

- Developed a code to identify Satellite Galaxies
  → Set this up using Boötes I
- Showed using the differential Image Maps that over densities are found
  → Took into account spatial completeness as well as star/galaxy probability
- Further tweaks need to be made
  → Experimenting with different values of σ_1
  → Add in dust effects as well as making S/N maps
- Can now run the code on entire PS1 sky