

Diffuse Light and Crowded Fields: BCG Photometry with Galfit

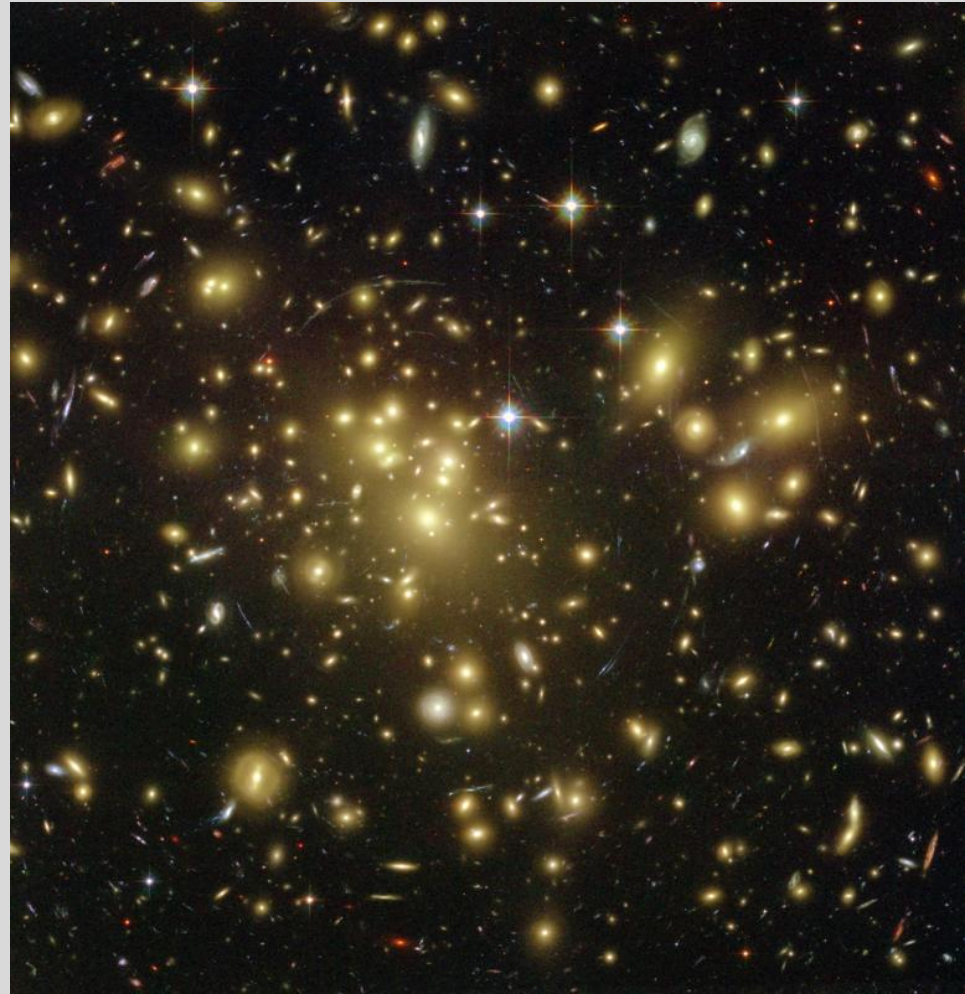
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Galaxy Clusters And Their Brightest Members

- Galaxy Clusters - the most massive, gravitationally bound structures in the Universe.
 - $10^{14} M_{\odot}$ - $10^{15} M_{\odot}$
 - Comparison: our Galaxy has a mass on the order of $10^{11} M_{\odot}$
 - Fairly new to the Universe
- Brightest cluster galaxy (BCG)
 - The brightest, most massive galaxy in the cluster.
 - Resides in the bottom of the gravitational potential well.
 - Surrounded by diffuse intracluster light (ICL)



Example of a cluster from HST: Abell 1689

BCG Photometry in Stripe 82

Measuring BCG light intensity (photometry) can be difficult

- Crowded cluster core
- Diffuse ICL

Our Goal:

Better BCG Photometry

Our Data:

- 42 galaxy clusters in Stripe 82 of SDSS
- Co-added to improve signal
- An issue: no PSFs given
 - PSF - a model of how light from a point source is blurred



2.5 m SDSS dedicated telescope at Apache Point, New Mexico

Galfit – A Model Fitting Algorithm

- A radial profile of intensity

$$I = f(r)$$

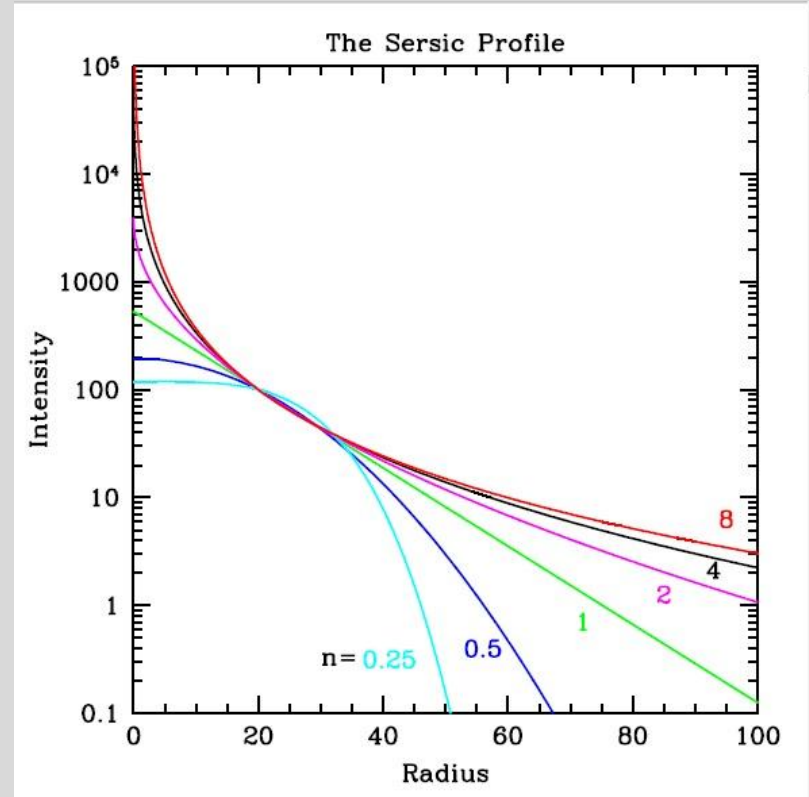
- An azimuthal profile of isophotal shape

$$r = g(x,y)$$

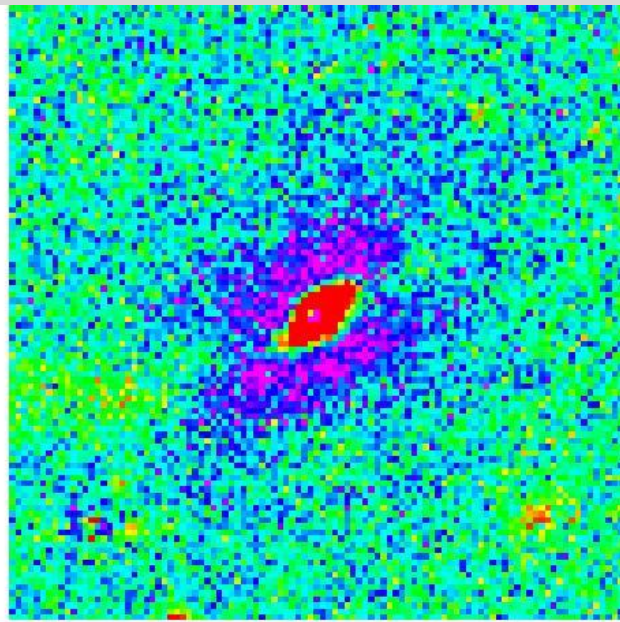
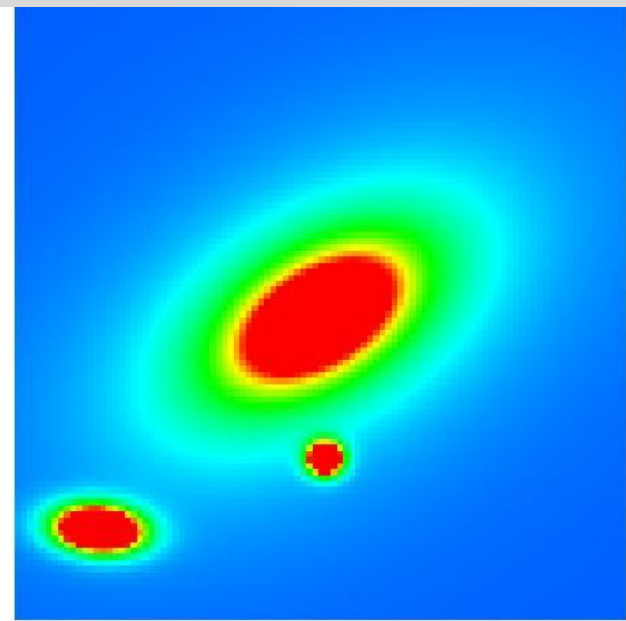
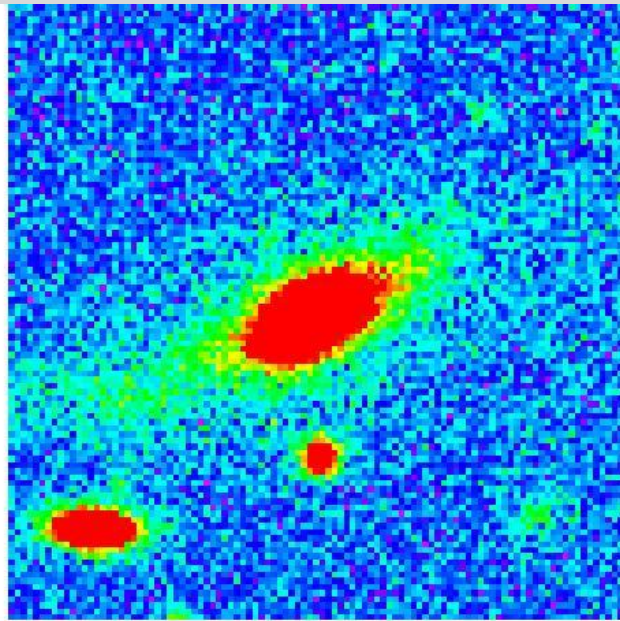
- Goodness of fit determined by normalized chi-squared. A good fit should be around 1.

$$\chi^2_\nu = \frac{1}{N_{\text{dof}}} \sum_{x=1}^{nx} \sum_{y=1}^{ny} \frac{(\text{flux}_{x,y} - \text{model}_{x,y})^2}{\sigma_{x,y}^2}$$

- Varies fit until changes in χ^2_ν become small.



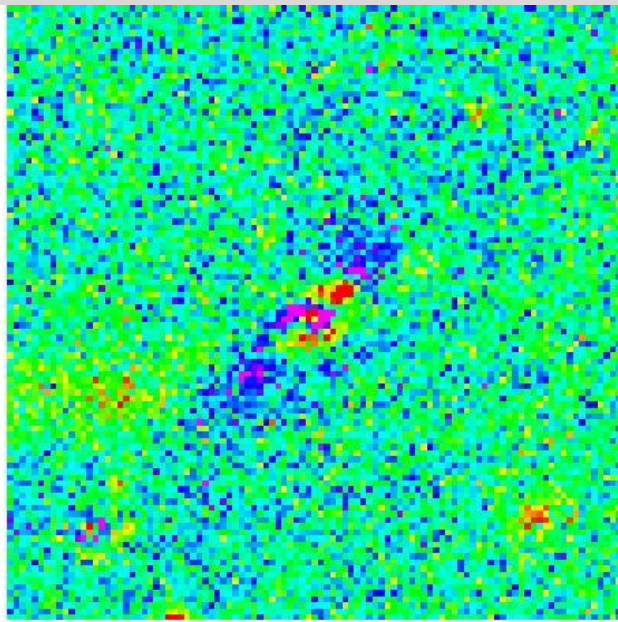
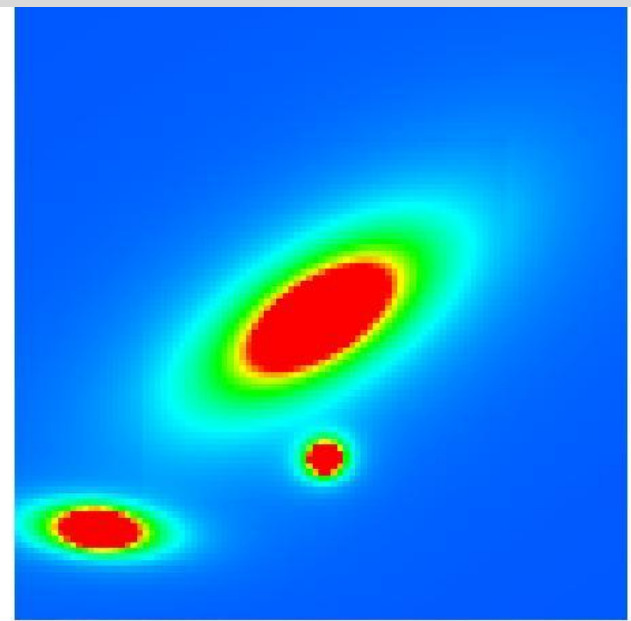
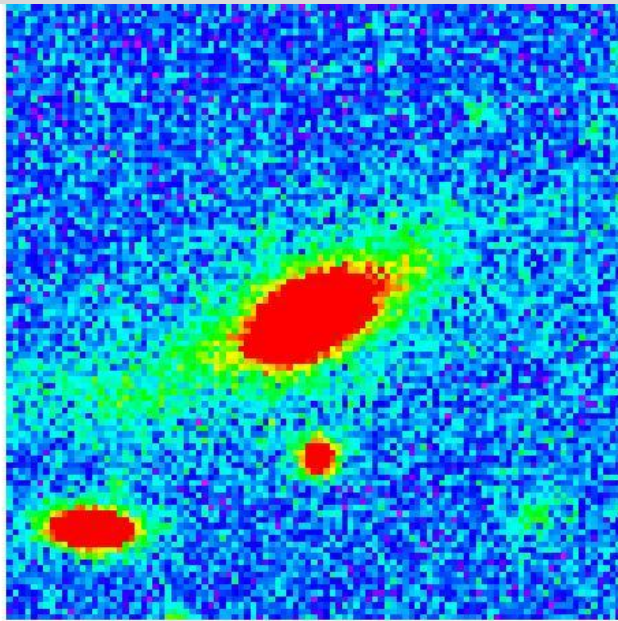
$$\Sigma(r) = \Sigma_e \exp \left[-\kappa \left(\left(\frac{r}{r_e} \right)^{1/n} - 1 \right) \right]$$



Importance of the PSF

- Galfit convolves the PSF with the radial profile
- Without a PSF, sersic profile doesn't fit BCG well

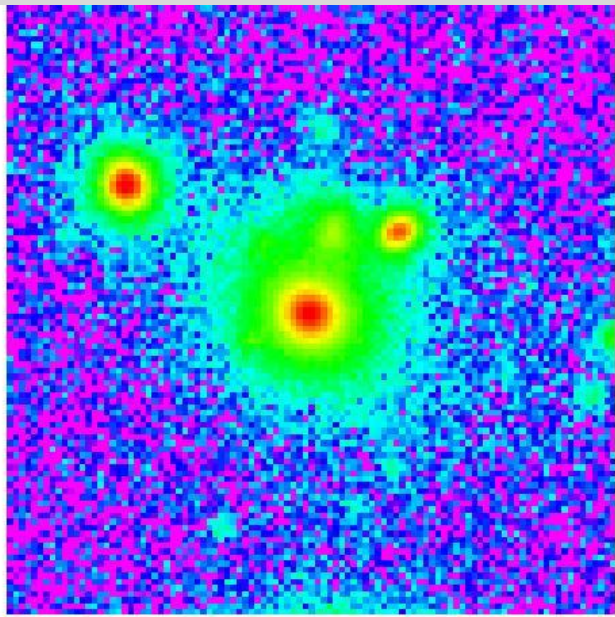
Mag = 16.4
 $R_e = 21.3$



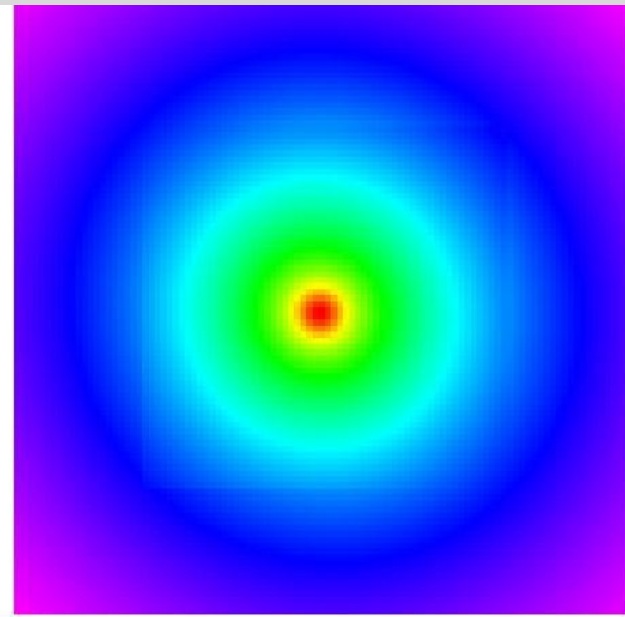
Importance of the PSF

- Same input as before, but with a convolved PSF
- PSF approximated by a gaussian profile with a FWHM derived from manual iteration

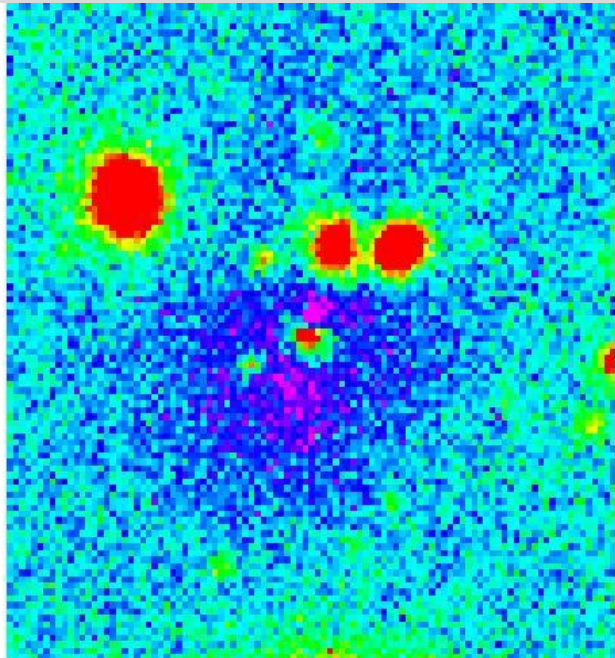
Mag = 16.8
 $R_e = 11.1$



0.2 0.4 0.6 0.8 1



0.2 0.4 0.6 0.8 1

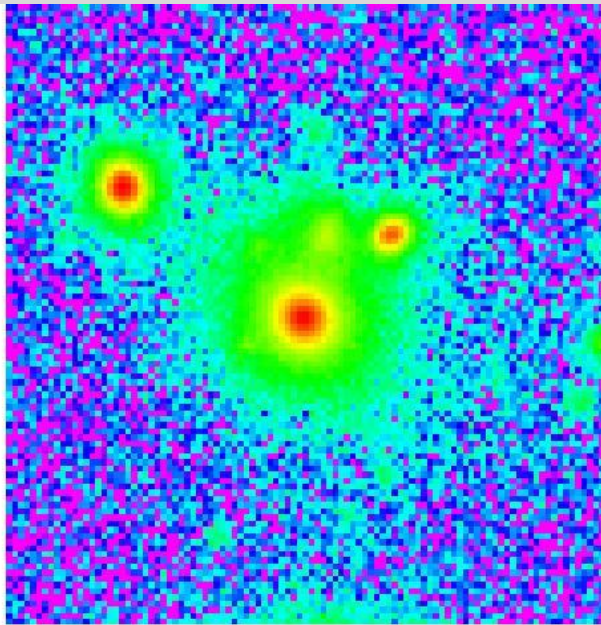


-0.03 -0.02 -0.01 0 0.01 0.02 0.03 0.04 0.05 0.06

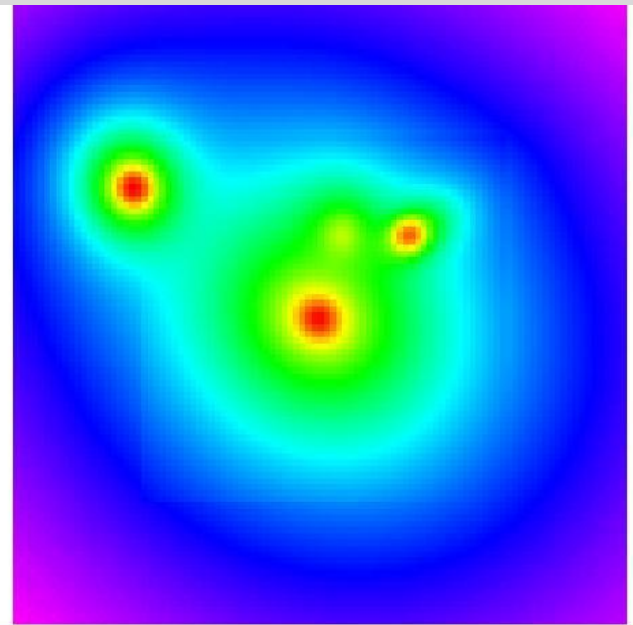
Fitting BCGs in Crowded Fields

- A single component fit of the BCG, ignoring the other bright objects in the field.
- Galfit tries to compensate for the other object, leading to a overall poor fit.

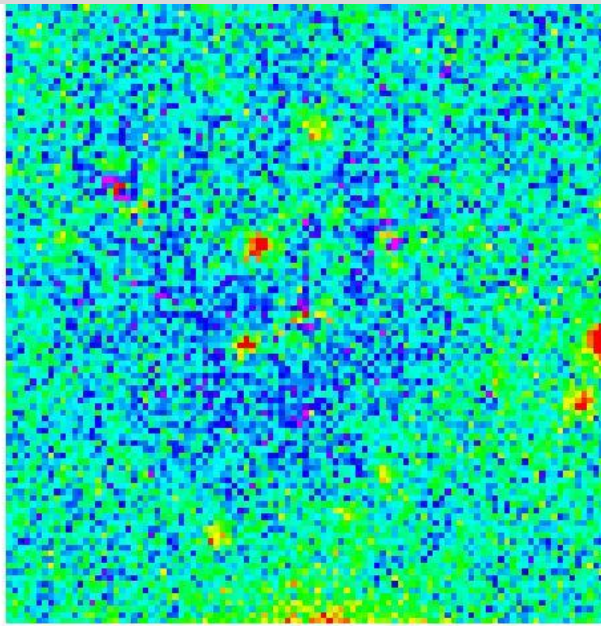
Mag = 15.8
 $R_e = 25.9$



0.2 0.4 0.6 0.8 1 1.2



0.2 0.4 0.6 0.8 1 1.2



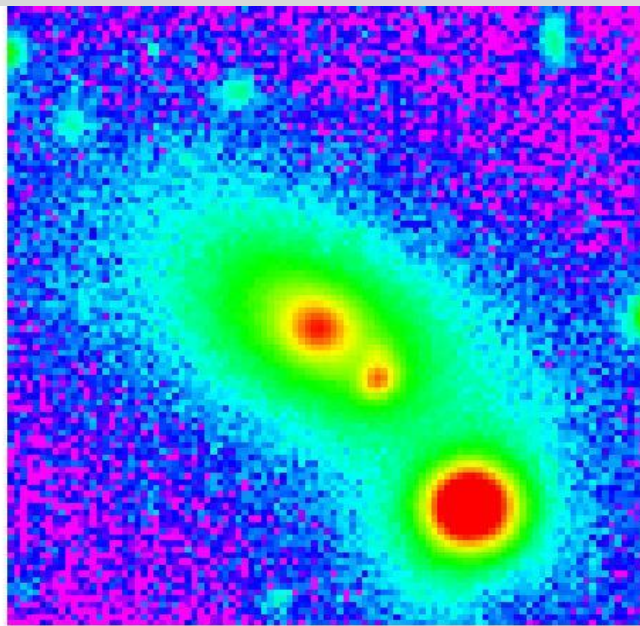
-0.03 -0.02 -0.01 0 0.01 0.02 0.03 0.04

Fitting BCGs in Crowded Fields

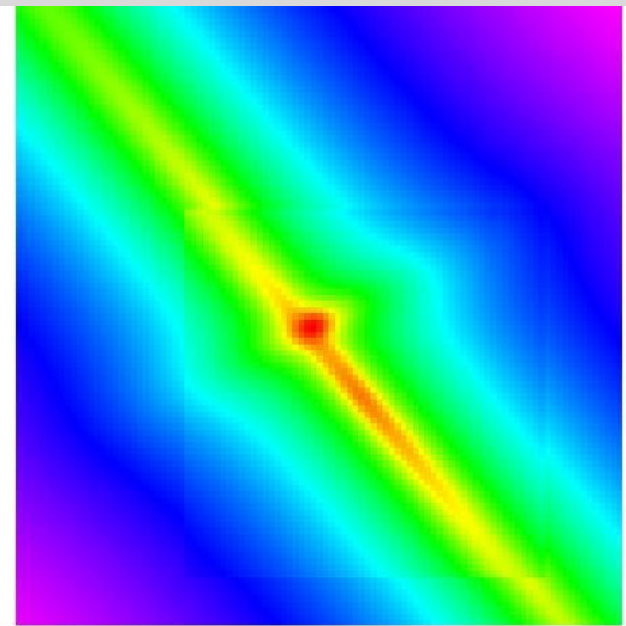
- A multi-component model. Note that BCG fit differs from previously.
- Residuals look much flatter.

Mag = 16.2

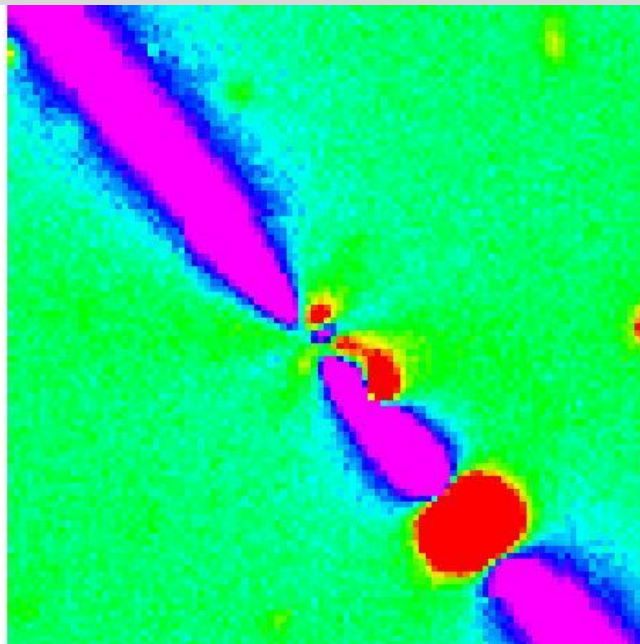
$R_e = 17.8$



0.2 0.4 0.6 0.8 1 1.214



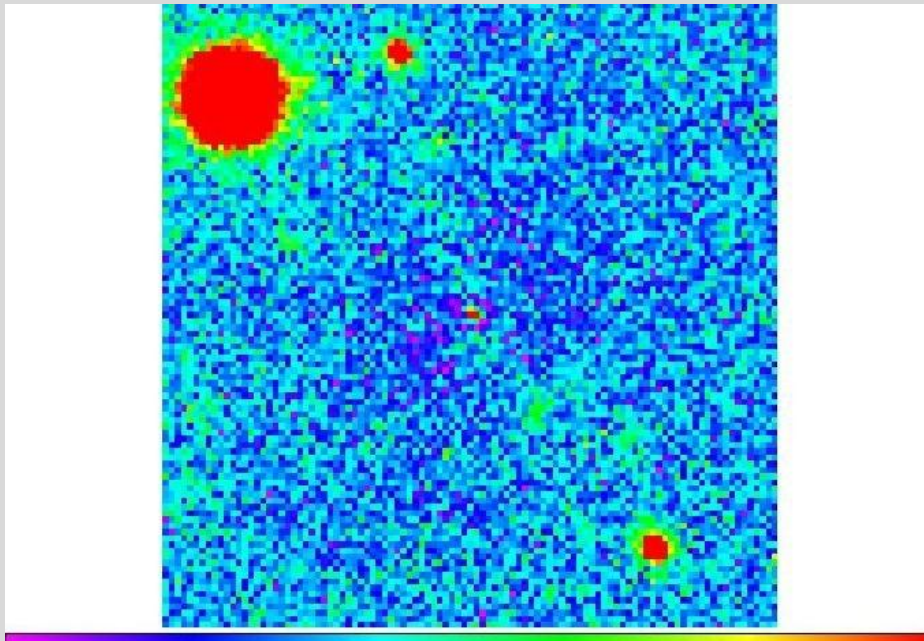
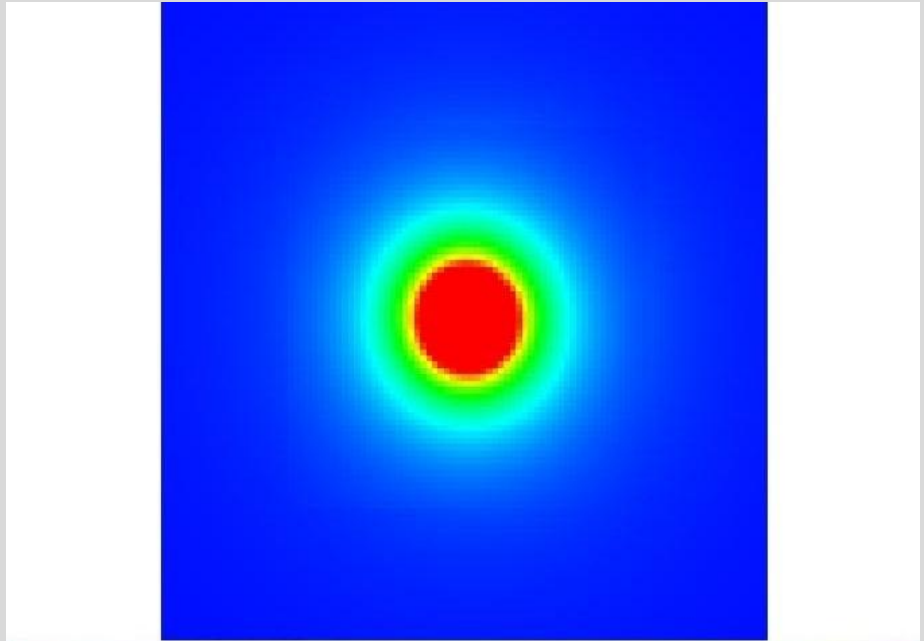
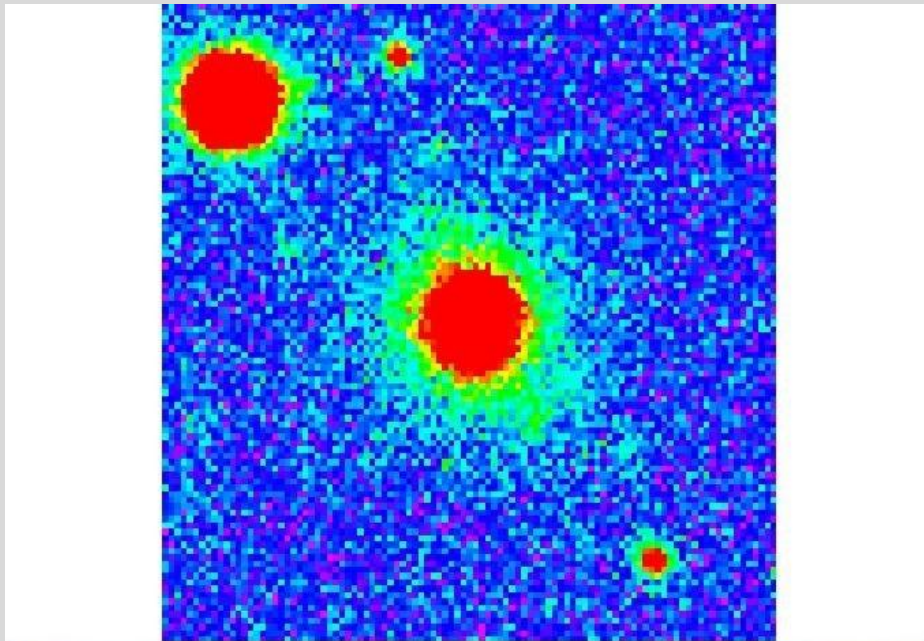
0.2 0.4 0.6 0.8 1 1.214



-0.1 -0.08 -0.06 -0.04 -0.02 0 0.02 0.04 0.06 0.08 0.1

Masking of Bright Objects

- A two component fit without masking a saturated star in the bottom right hand corner.
- Galfit tries to compensate for the star light, leading to an incorrect azimuth profile.

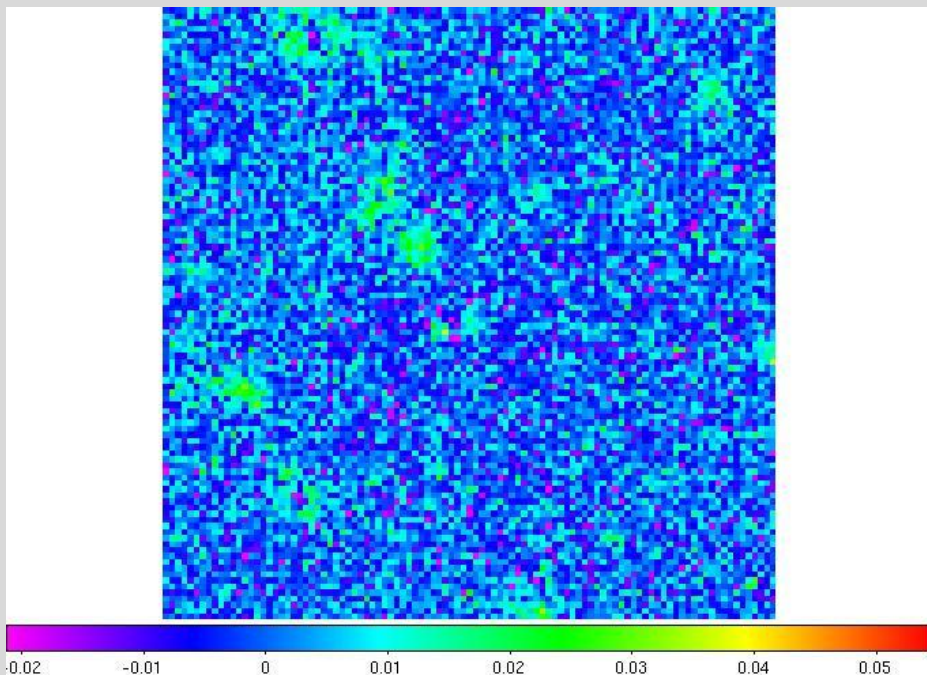
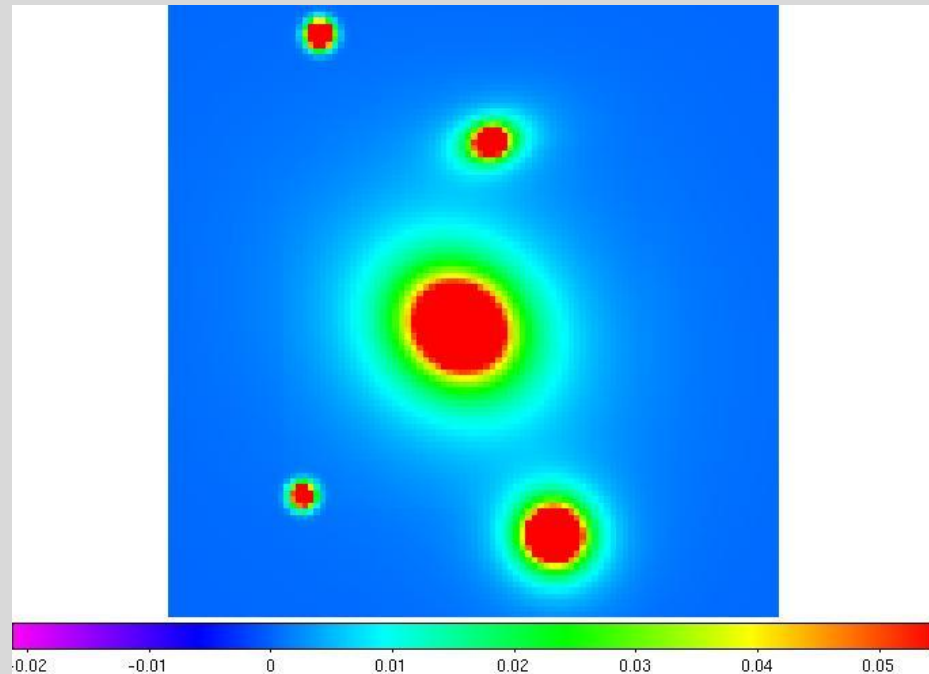
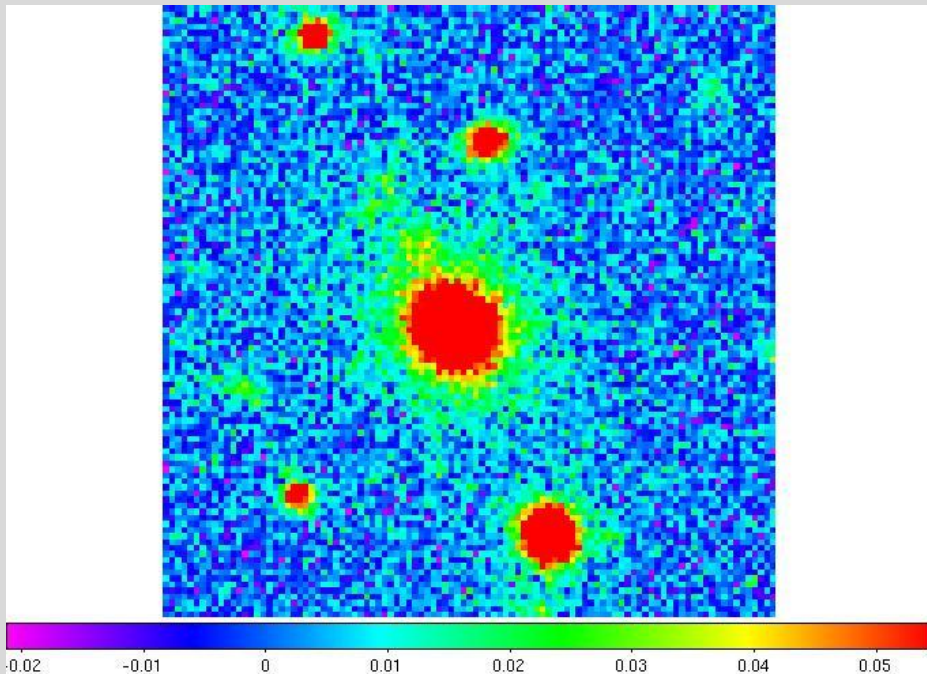


The Chi-Squared Problem

- A single-component model, ignoring the other objects in the field.
- Since the other objects aren't very bright, Galfit can still do a successful fit of the BCG. However...

Mag = 16.9
R_e = 11.2

$\chi^2_v = 230.080$



A Great Multi-Component Model

- A five component model, using sersics and psfs.
- A great residual image and good chi-squared.

Mag = 17.5
R_e = 8.2

$\chi^2_v = 0.950$

Future Work


- Continue to better the BCG fits with Galfit
- Work with an IDL code to see if residual light has radial patterns
- Automate Galfit using Python as a wrapper, enabling us to do decent photometry with a large number of clusters

References

Koester, Benjamin P. et al. 2007, ApJ, 660, 221
Koester, B. P. et al. 2007, ApJ, 660, 239
Krick, J. E. and Bernstein, R. A. 2006, ApJ, 131, 168
Peng, Chien Y., Galfit User's Manual
Peng, Chien Y. et al. 2002, ApJ, 124, 266
Sloan Digital Sky Survey Website (sdss.org)
Voit, Mark G. 2005, RvMP, Vol. 77, No. 1

Acknowledgments

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- The University of Michigan for giving me this opportunity
- The National Science Foundation for funding this great program

A deep-field astronomical image showing a vast number of galaxies in a cluster. The galaxies are of various shapes and sizes, mostly yellow and white, set against a black background. A prominent red star-like object with blue and white diffraction spikes is located in the upper right quadrant. The text "Any Questions?" is overlaid in white, sans-serif font in the center of the image.

Any Questions?