Application of CHEF galaxy models to photometry

Haga clic para modificar el estilo de subtítulo del patrón

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GALFIT/GALAPAGOS, SDSS photometry
(Parametric fitting: analytical profiles)

- Not suitable for galaxies with irregular features.
- Dependence on a priori knowledge.
- High interactivity from the user.

Shapelets
(Non-parametric fitting: orthonormal bases)

- Ringing effects.
- Gaussians bound the light coming from the disk of extended galaxies: photometry is **underestimated**.

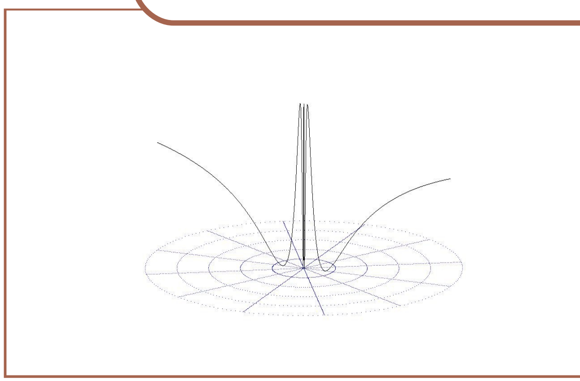
SExtractor

- Background is overestimated.
- Flux coming from the disk of extended galaxies is removed: photometry is **underestimated**.

The CHEF polar basis is separable in *r* and *θ* **(Jiménez-Teja & Benítez, 2012)**

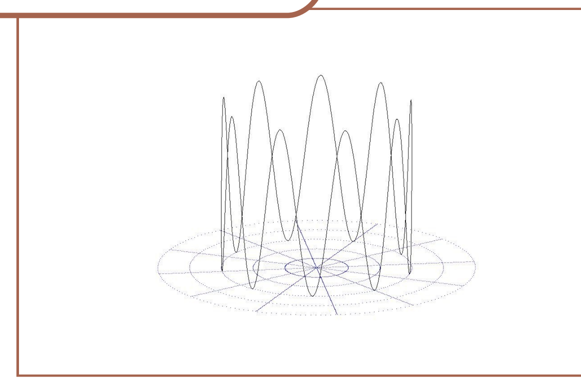
Chebyshev rational functions in *r*

$$TL_n(r;L) = T_n\left(\frac{r - L}{r + L}\right)$$



Fourier series in *θ*

$$e^{imq}$$



$$\{\phi_{nm}(r,q;L)\}_{nm} = \left\{\frac{1}{Cp} TL_n(r;L) e^{imq}\right\}_{nm}, \text{ with } C = \begin{cases} \sqrt{2}, & \text{if } n = 0 \\ 1, & \text{cc.} \end{cases}$$

CHEF set is a **basis** of the Hilbert space $\Lambda^2([0,+\ )\ \ [-p,p],\langle\ ,\ \rangle)$, with

$$\langle f,g\rangle = \int_0^{+\infty}\int_{-\pi}^{\pi} f(r,\theta)\overline{g(r,\theta)}\,\frac{1}{r+L}\sqrt{\frac{L}{r}}\,d\theta\,dr$$

Any smooth function *f* can be decomposed into

$$f(r,q) = \frac{1}{Cp}\sum_{n=0}^{+}\sum_{m=-}^{+} f_{nm}\,TL_n(r)\,e^{imq}$$

where the **CHEF coefficients** are calculated by

$$f_{nm} = \frac{C}{2p^2}\int_{-p}^{p}\int_{0}^{+} f(z,f)\,TL_n(z)\,\frac{1}{z+L}\sqrt{\frac{L}{z}}\,e^{-imf}\,dz\,df$$

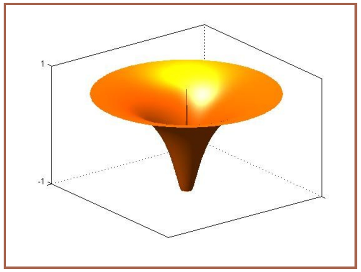
Chebyshev rational functions behave much better than Hermite polynomials when fitting the usual galaxy profiles (Sérsic or de Vaucouleurs) (Bosch 2010).

Just a few coefficients provide high accuracy over several orders of magnitude.

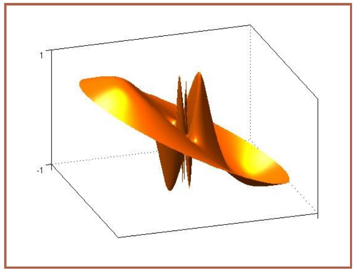
CHEFs visualization

Real components

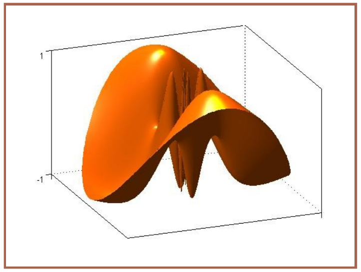
Imaginary components



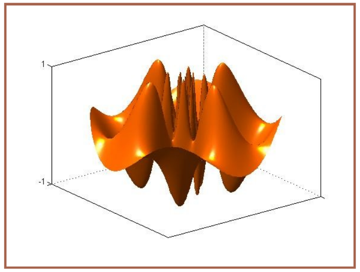
$n = 2, \quad m = 0$



$n = 6, \quad m = 1$



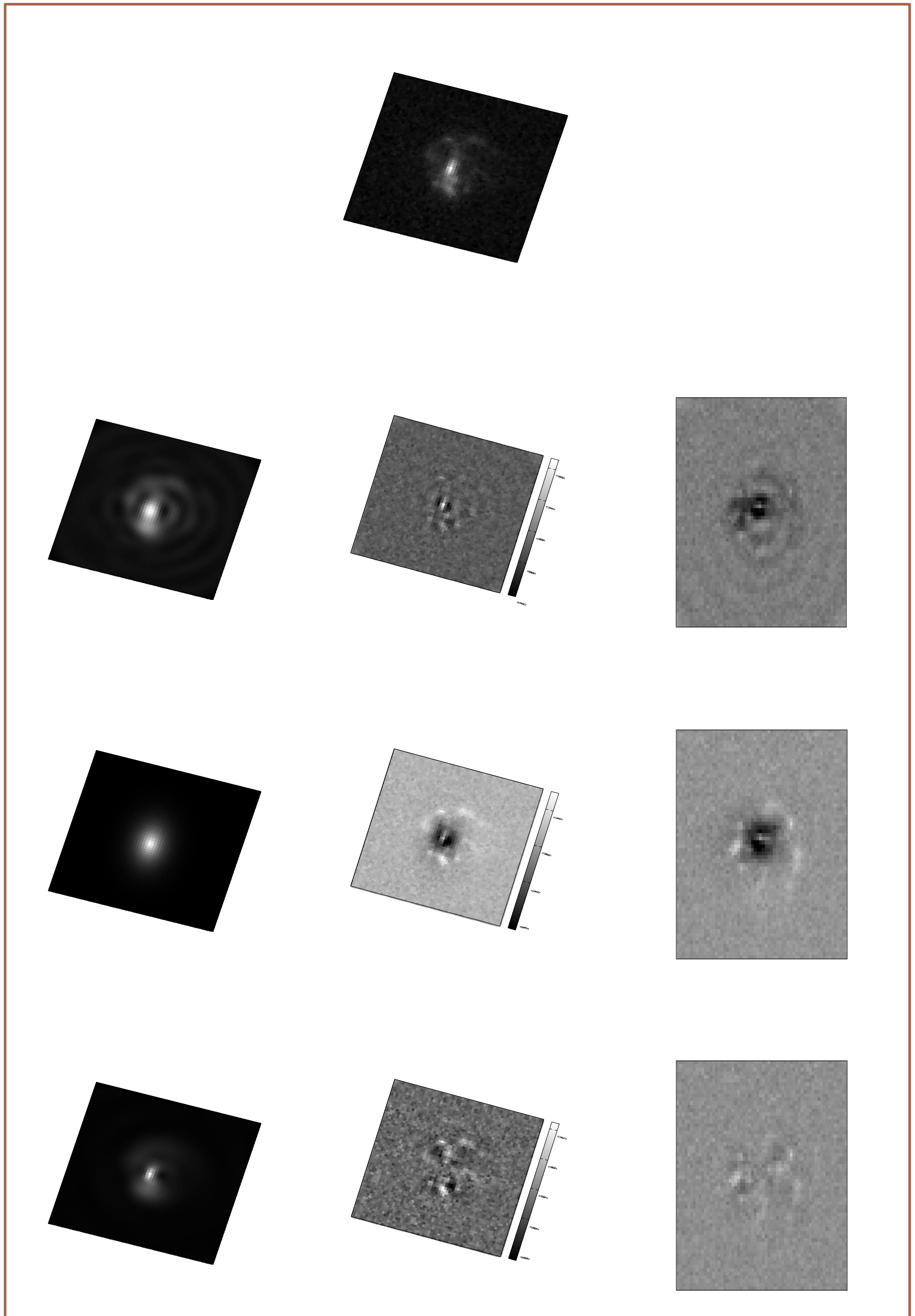
$n = 6, \quad m = 2$



$n = 10, \quad m = 4$

CHEFs performance examples

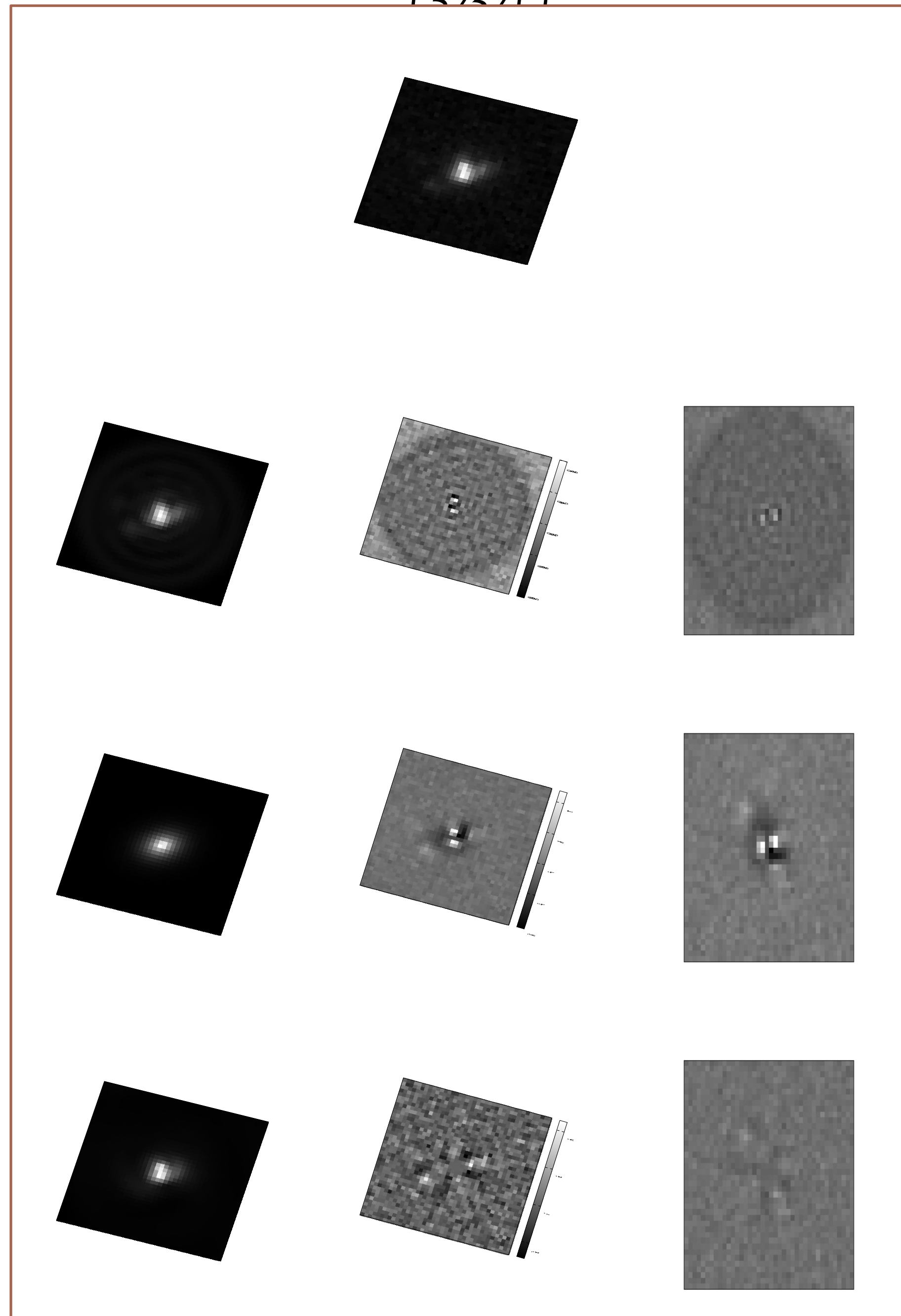
15/3/11



S

G

C



Photometry

Background removal: Estimation using the CHEF model outside the Kron ellipse

Original flux: $F = 2p \overset{+}{\underset{n=0}{}} f_{n,0} I_1^n$

Bayesian calculation in the presence of noise

$$F_B = \frac{\underset{i,j}{} \dfrac{M_{ij}}{d_{ij}^2}}{\underset{i,j}{} \dfrac{M_{ij}^2}{d_{ij}^2}} F$$

M = CHEF model

δ = background noise

Image simulation

1) **Elaboration of the catalogue:** UDF processing.
2) **Storing of the models:** number of coefficients, morphological parameters, scale size, centroid and coefficients values.
3) **Random selection of the models.**
4) **Evaluation of the models:** according to ALHAMBRA observational characteristics (pixel size, zero point, PSF…)
5) **Analytical calculation of the model magnitudes.**
6) **Addition of the models:** in randomly selected locations of the ALHAMBRA fields and with random rotations.
7) **Modeling the inserted sources:** using both CHEFs and Sextractor (if possible).
8) **Comparison:** measured vs real magnitudes (calculated in step 5)

CHEF total magnitudes vs Mag_auto

mAB sex - mAB real

mAB real

CHEF total magnitudes vs Mag_auto

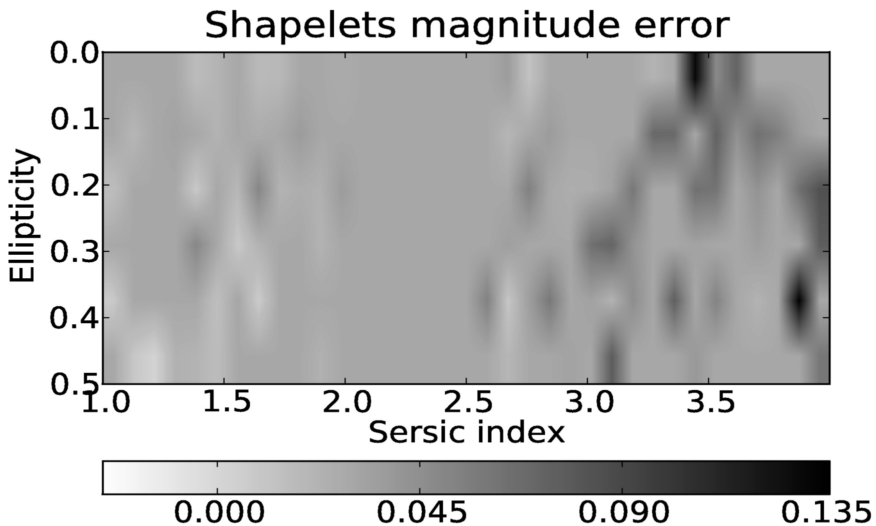
mAB CHEFs - mAB real

mAB real

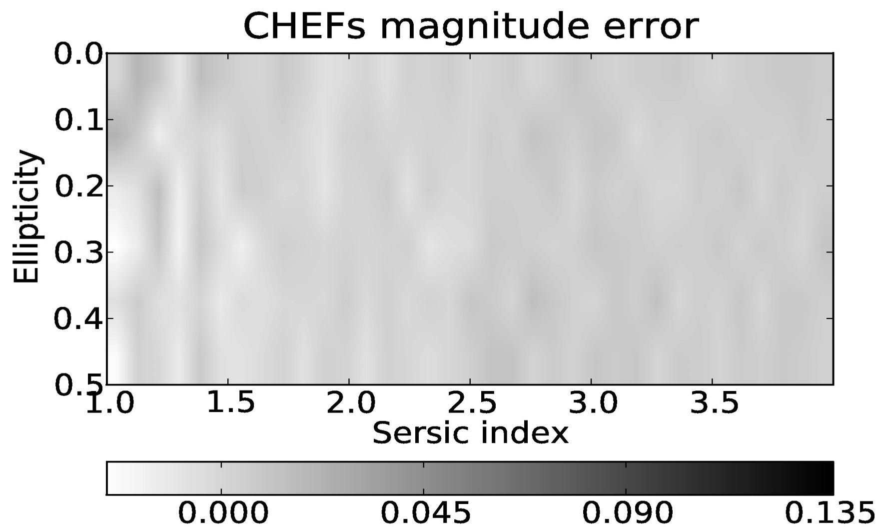
Conclusions

- CHEFs constitute a set of compact bases of finite-energy functions, what allows us to model objects with high accuracy and few components.
- We have developed many CHEF applications, such us the PSF deconvolution, the fast application to large surveys with several filters, the removing of BCGs in clusters, and the calculation of different photometric and morphological parameters.
- Three different tests have been carried out to check the photometric measurements: classical profile simulations (comparison with shapelets), real data from ALHAMBRA, and realistic simulations in ALHAMBRA (comparison with Sextractor).
- CHEFs have shown to be very competitive in measuring photometry, without any kind of bias and great level of accuracy, so they would be considered as an important alternative to Sextractor.

Sample of 350 mock galaxy images of 100x100 pixels, with Sérsic profiles whose index ranges from 0.5 to 4 and sheared with different levels of ellipticity. Gaussian noise added.



(a)



(b)

Maximum error of ≈ 13.5%

Maximum error of ≈ 1.6%

NGC 1097

$$I_p^n = \begin{cases} 2 \sum_{j=0}^{n} \binom{n}{j} (-1)^j L^{-j/2} \dfrac{R^{p+j/2+1}}{2p+j+2} \mathrm{Re}\, e^{inp/2} i^{n+j} {}_2F_1\left(n, 2p+j+2, 2p+j+3; \dfrac{-i\sqrt{R}}{\sqrt{L}}\right), & \text{if } n>0 \\ \dfrac{R^{p+1}}{p+1}, & \text{if } n=0 \end{cases}$$

Flux: $F = 2p \sum_{n=0}^{+} f_{n,0} I_1^n$

Rms radius: $R^2 = \dfrac{2p}{F} \sum_{n=0}^{+} f_{n,0} I_3^n$

Centroid: $x_c + i y_c = \dfrac{2p}{F} \sum_{n=0}^{+} f_{n,1} I_2^n$

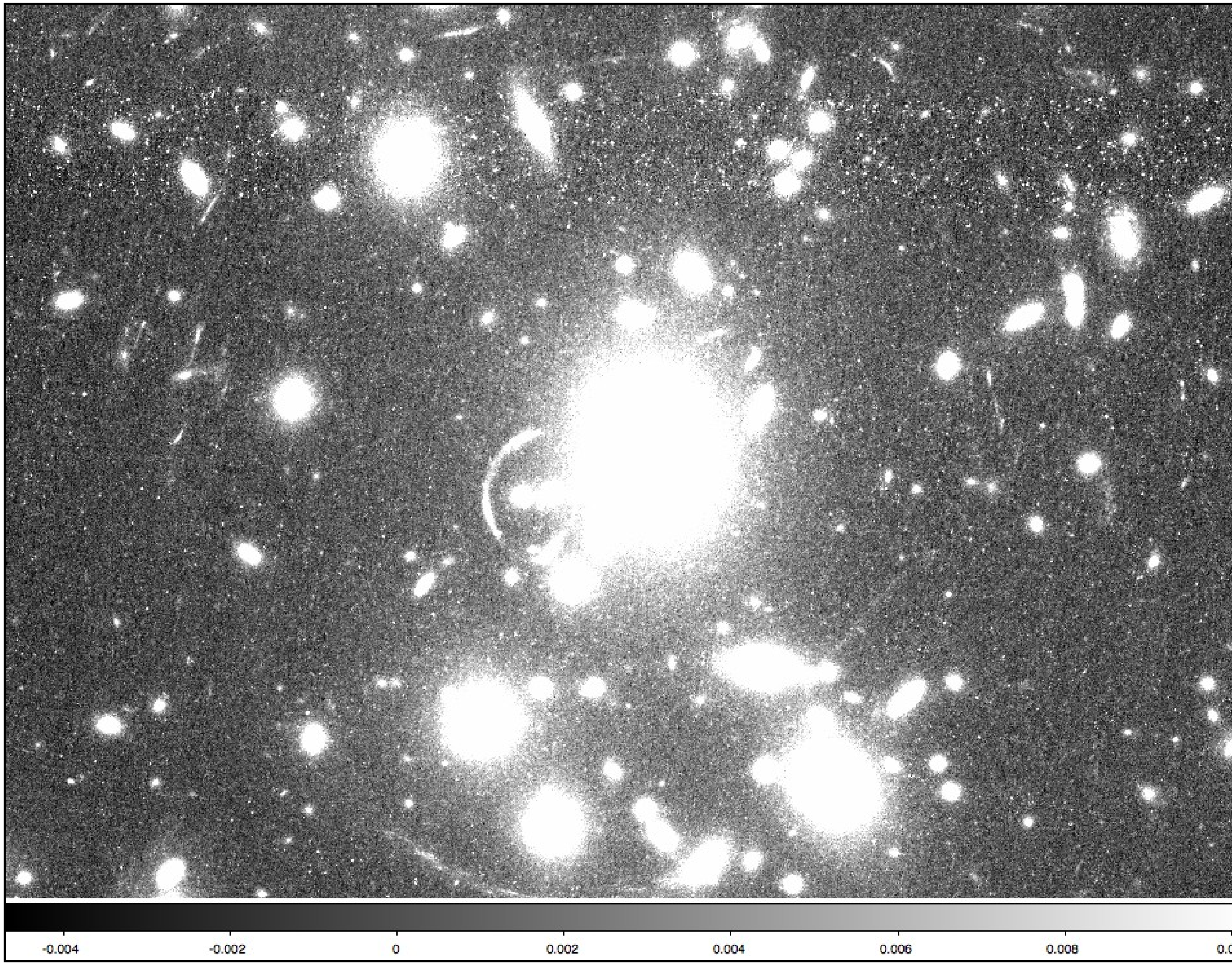
Ellipticity: $e = \dfrac{\sum_{n=0}^{+} f_{n,-2} I_3^n}{\sum_{n=0}^{+} f_{n,0} I_3^n}$

Shear estimator:

$$\varepsilon = \frac{\sum_{n=0}^{+} f_{n,-2} I_n^3}{\left[\sum_{n=0}^{+} f_{n,0} I_n^3 + \dfrac{\sqrt{2}}{2} \sum_{i,j=0}^{+} \left(-f_{i,-2} f_{i,2} - f_{i,2} f_{j,-2} + (f_{i,-2} + f_{i,2} + f_{i,0}) f_{j,0} + (f_{j,-2} + f_{j,2} + f_{j,0}) f_{i,0}\right) I_3^i I_3^j\right]^{1/2}}$$

ABELL1703
(F850)

(Zitrin et al, 2010)



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