Image Deconvolution by Multiscale Methods

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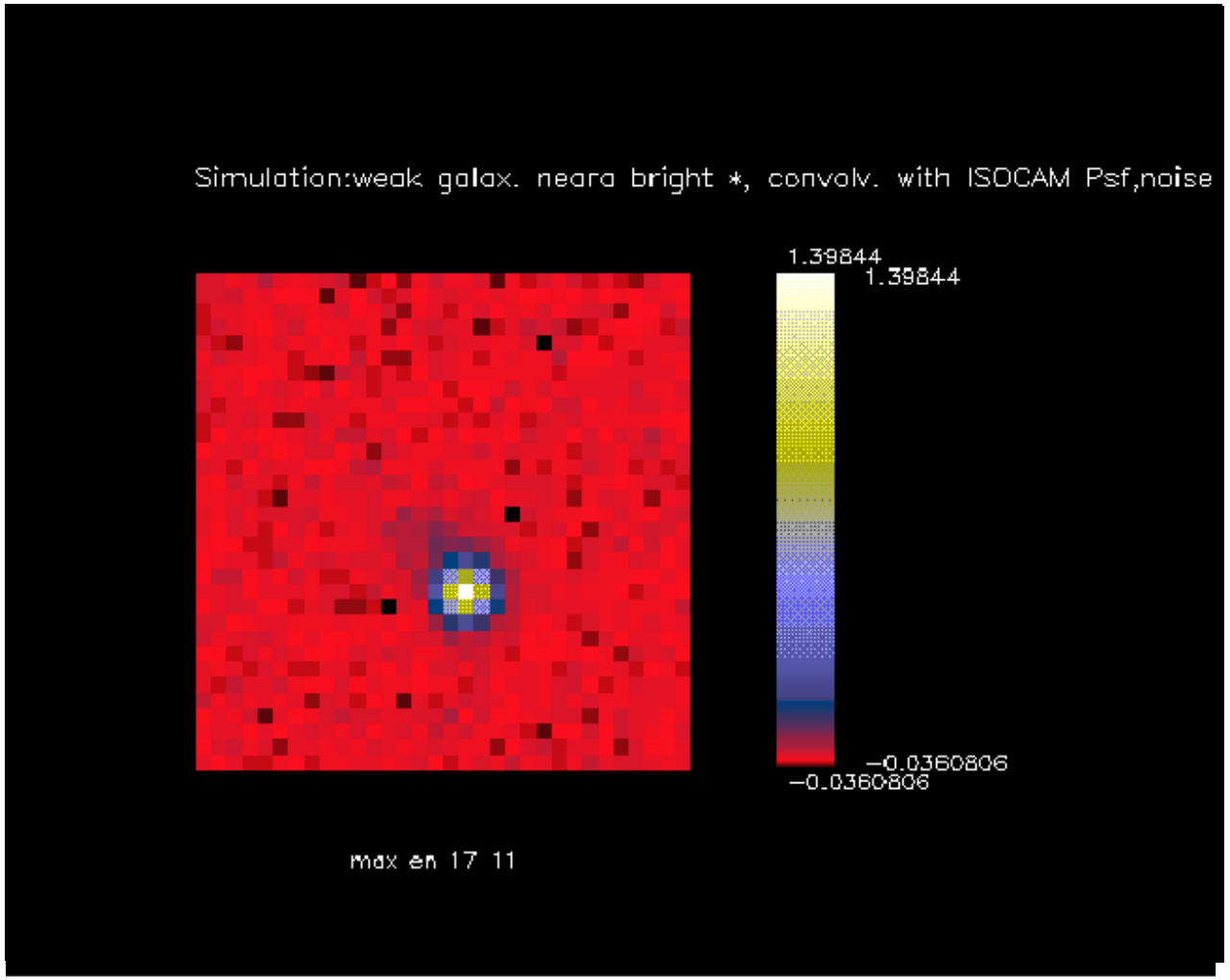

Simulation:weak galax. neara bright *, convolv. with ISOCAM Psf,noise
1.39844
1.39844
-0.0360806
-0.0360806
max en 17 11

DECONVOLUTION METHODS IN ASTRONOMY

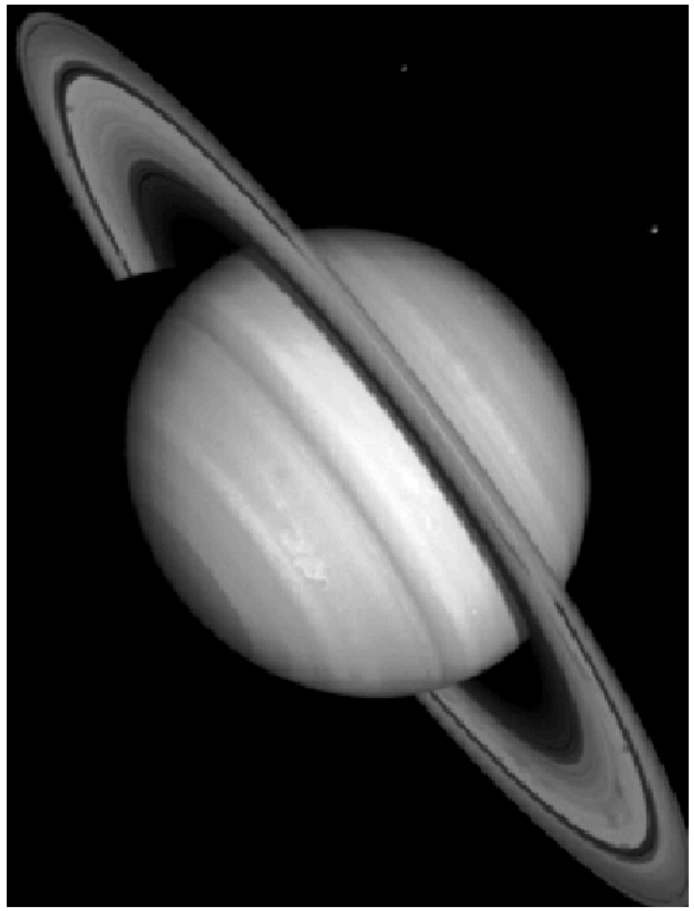
WITHOUT REGULARIZARION:

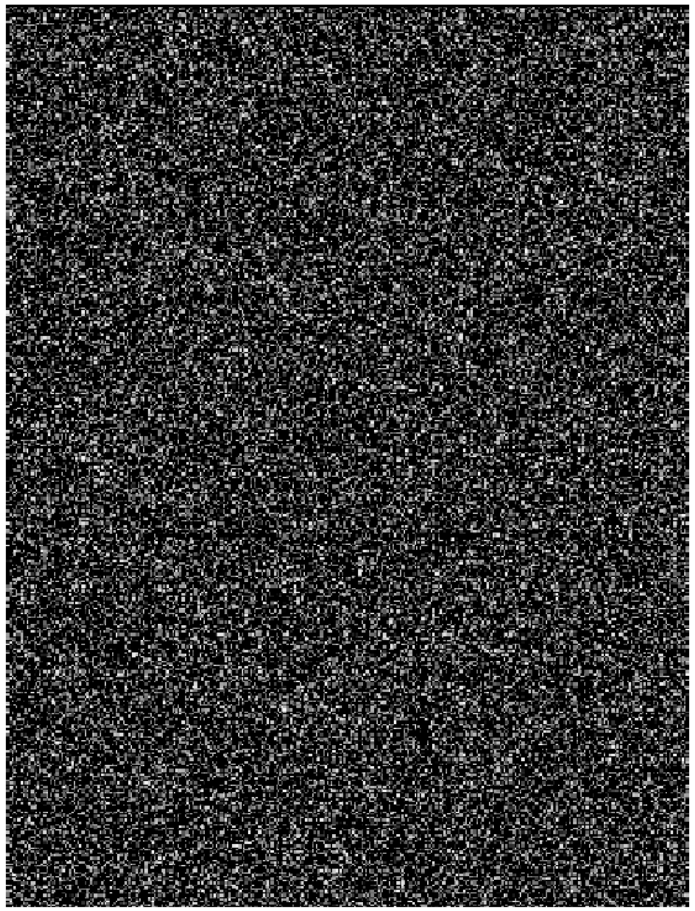
Richardson Lucy method → Noise amplification

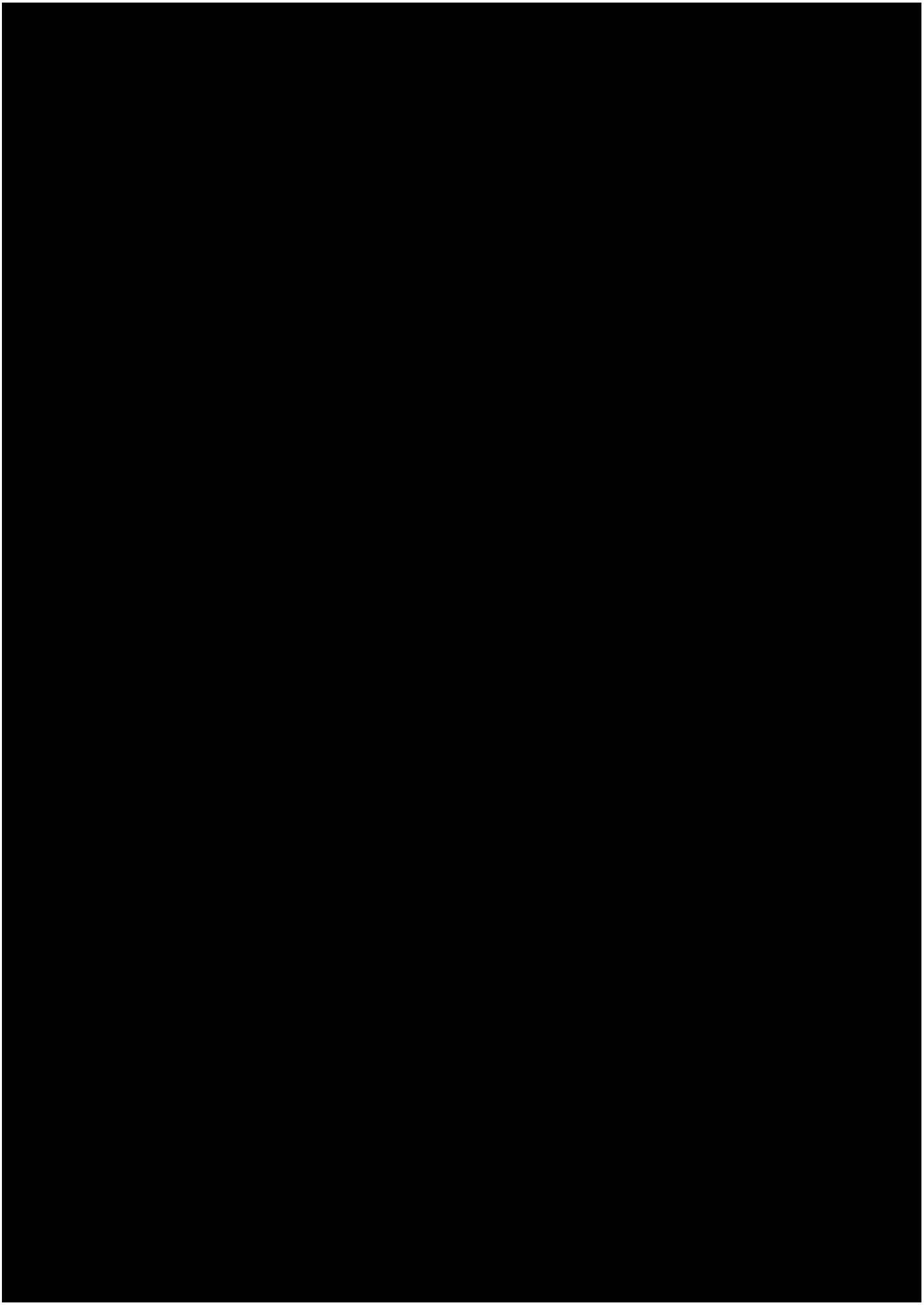
WITH REGULARIZATION

Maximum Entropy Method → Problem to restore stars

CLEAN METHOD → Problem to restore extended sources







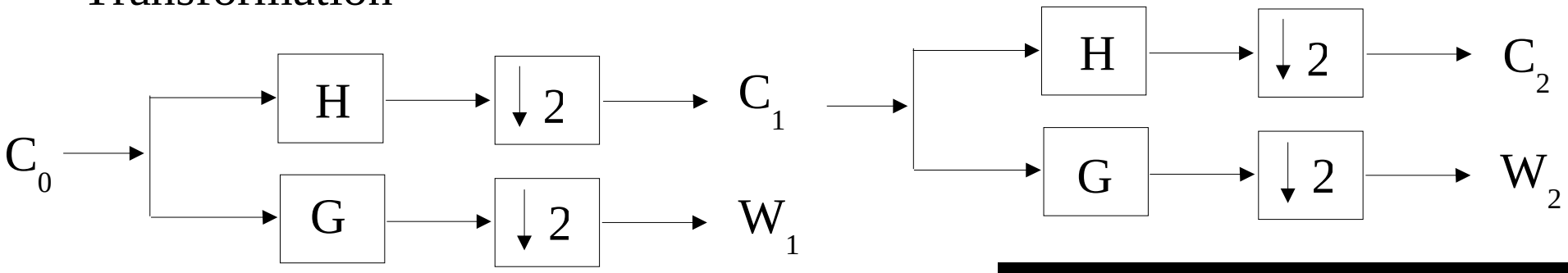
Multiscale Methods

. The bi-orthogonal wavelet transfrom.
. The undecimated wavelet transfrom (à trous algorithm).
. The isotropic wavelet transfrom (à trous algorithm).
. The Multiscale Median Transform
. New Constructions:
  - Ridgelet
  - Curvelet
  - Bandelet
  - Contourlet

The Othogononal Wavelet Transform (OWT)

$$s(l)=\sum_k c_{J,k}\phi_{J,l}(k)+\sum_k\sum_{j=1}^{J}\psi_{j,l}(k)w_{j,k}$$

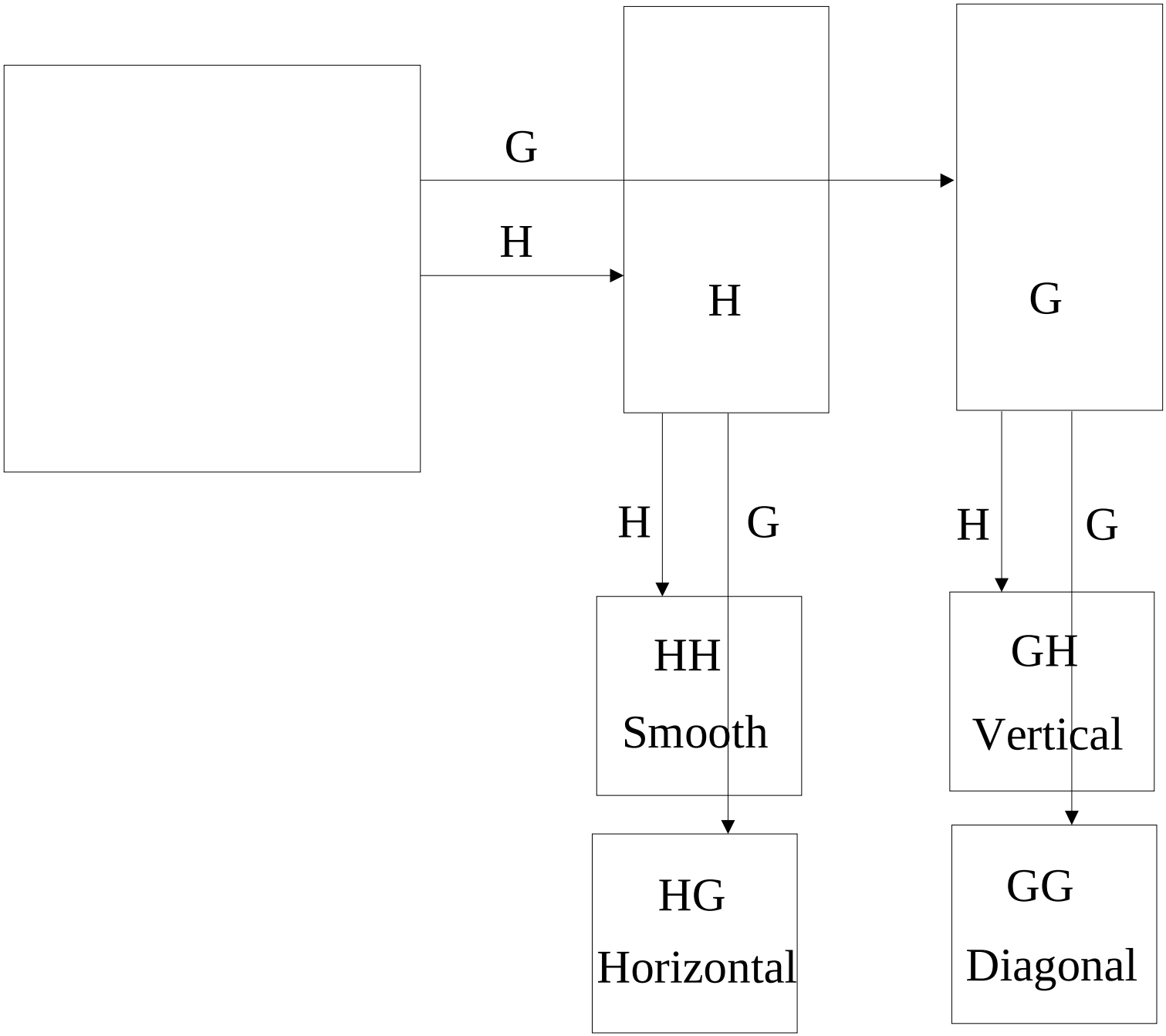
Transformation

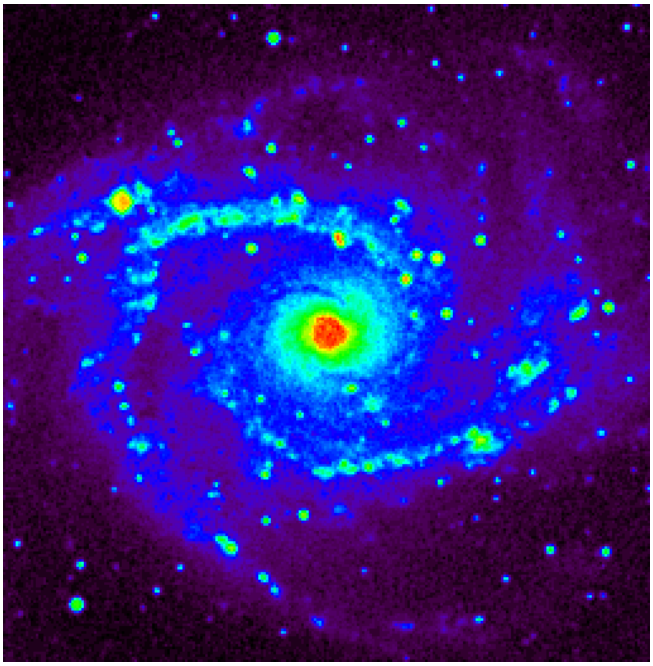


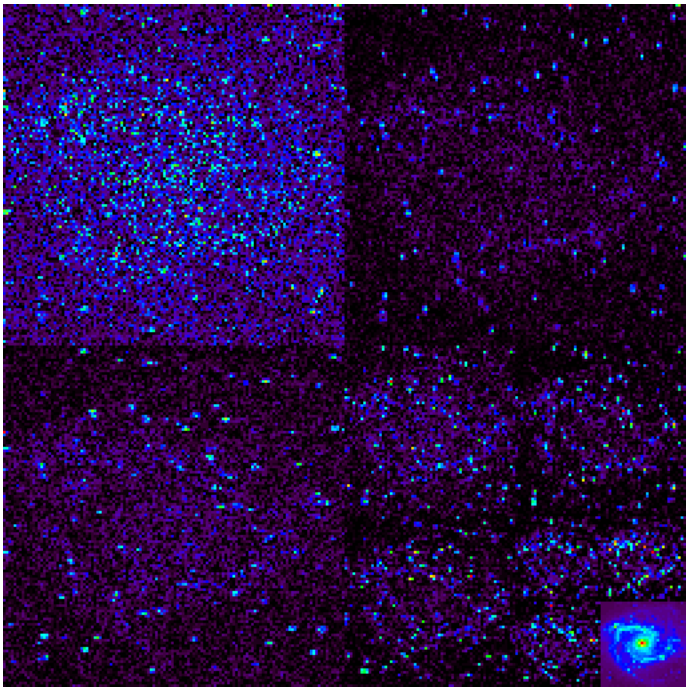
$$c_{j+1}=\sum_k h(k-2l)c_{j,k}$$
$$w_{j+1}=\sum_k g(k-2l)c_{j,k}$$

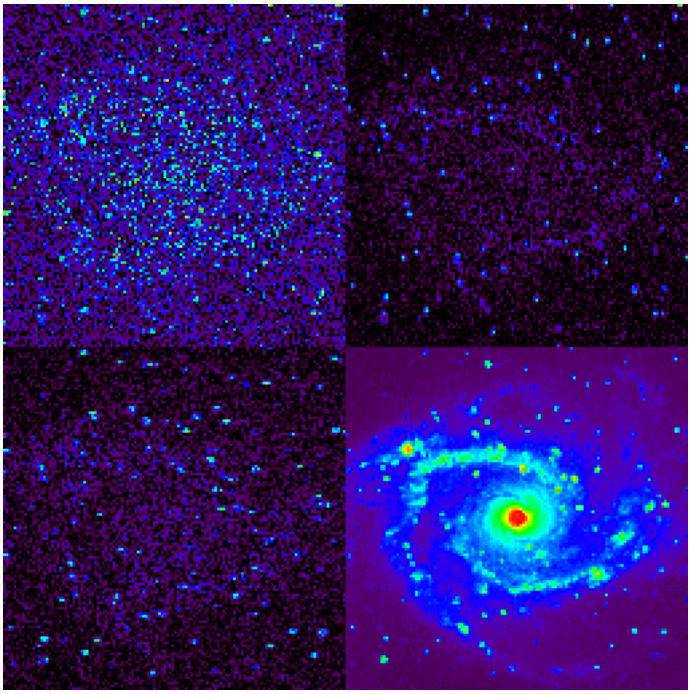
Reconstruction:

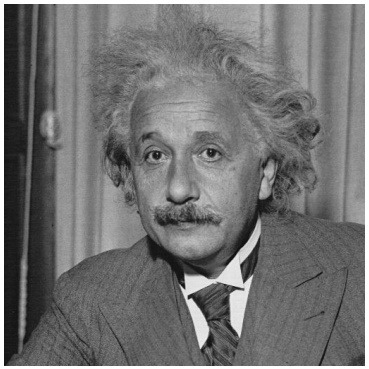
$$c_{j,l}=2\sum_k[c_{j+1,k}\tilde{h}(l+2k)+w_{j+1,k}\tilde{g}(l+2k)]$$


G
H
H
G
H
G
H
G
HH
Smooth
GH
Vertical
HG
Horizontal
GG
Diagonal

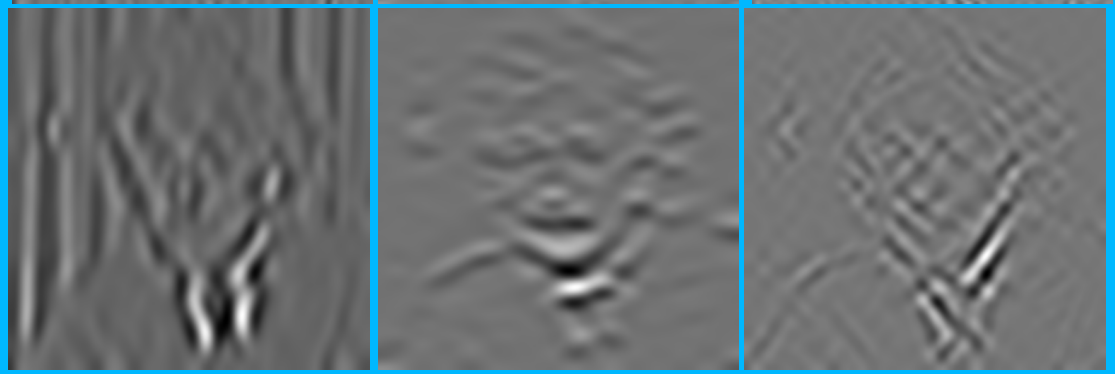


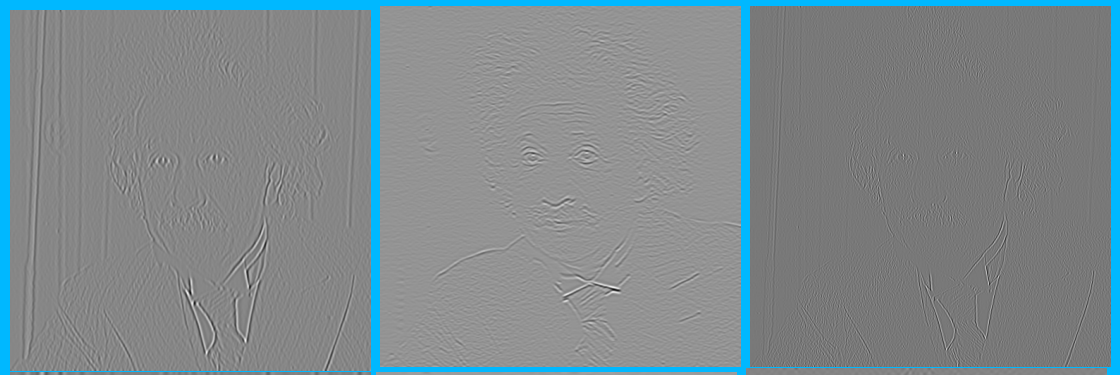




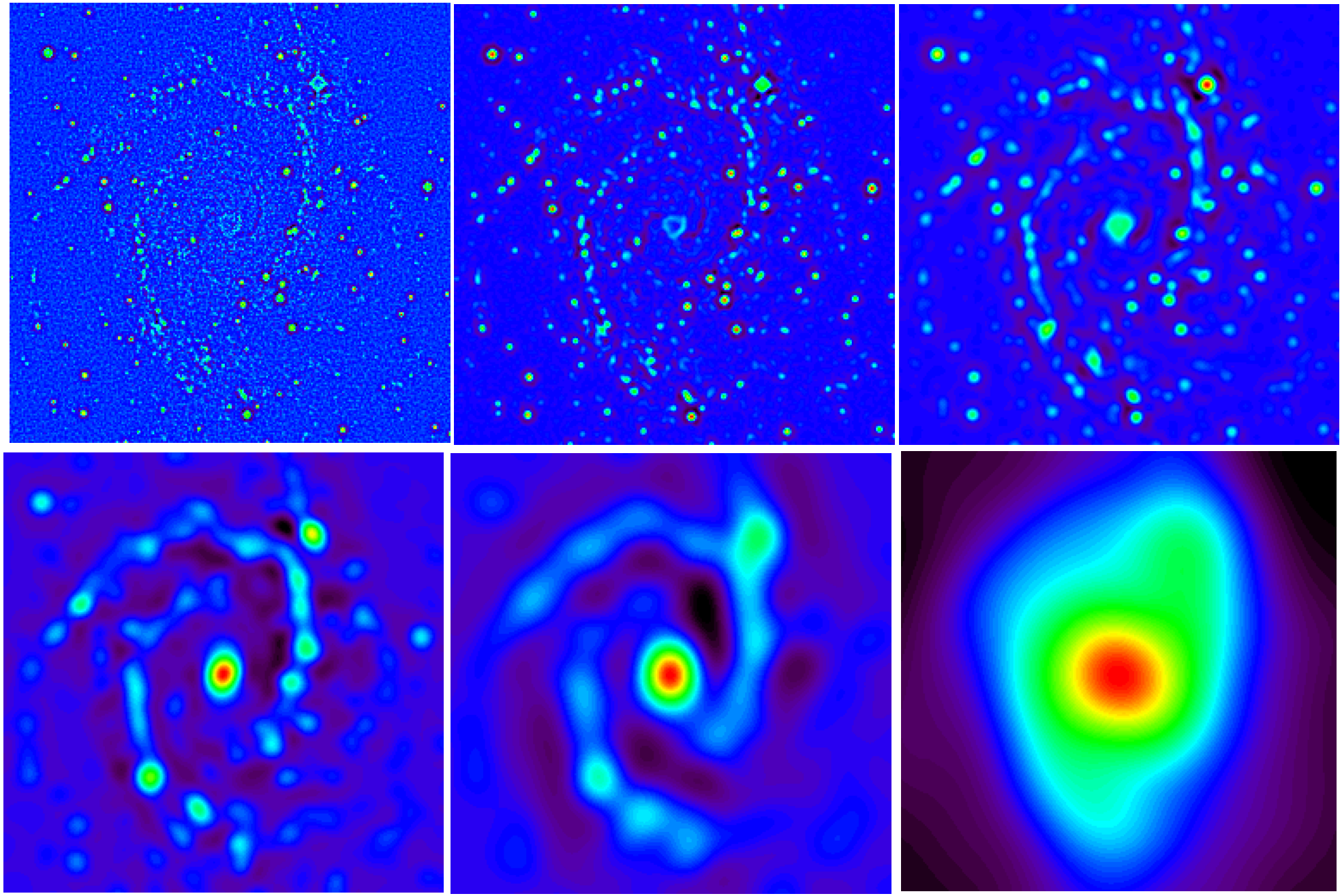


Undecimated Wavelet Transform



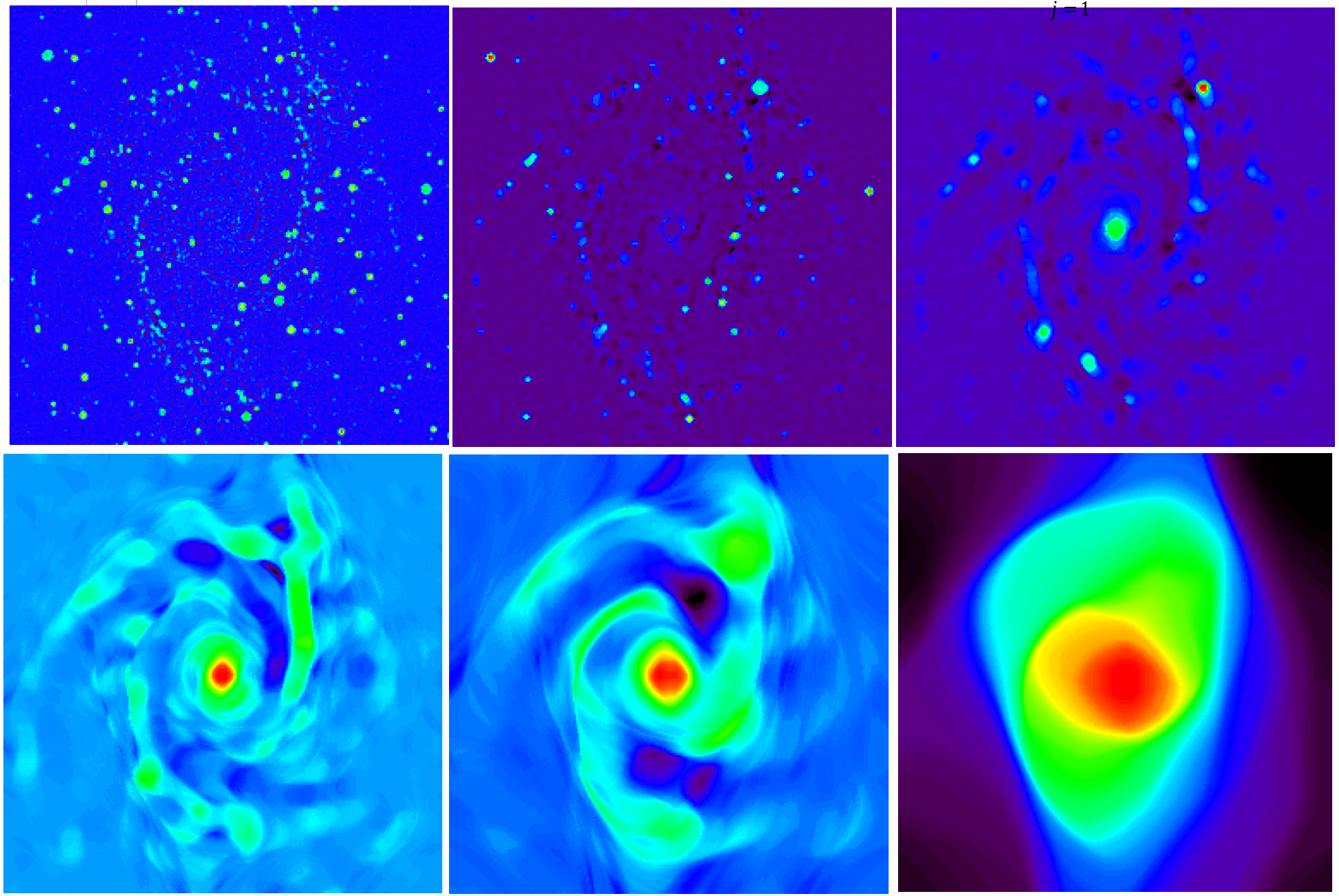


Isotropic Undecimated Wavelet Transform: $I(x,y) = c_J(x,y) + \sum_{j=1}^{J} w(j,x,y)$



Multiscale Median Transform:

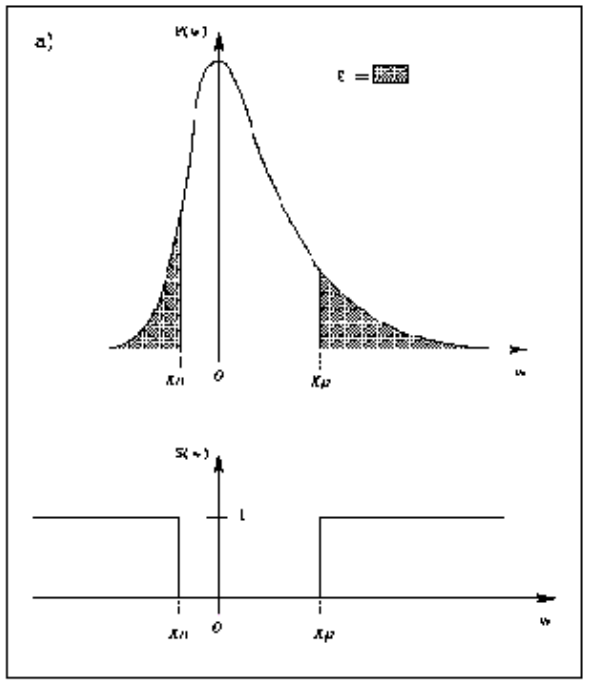
$$I(x,y) = c_J(x,y) + \sum_{j=1}^{J} w(j,x,y)$$



NOISE MODELING

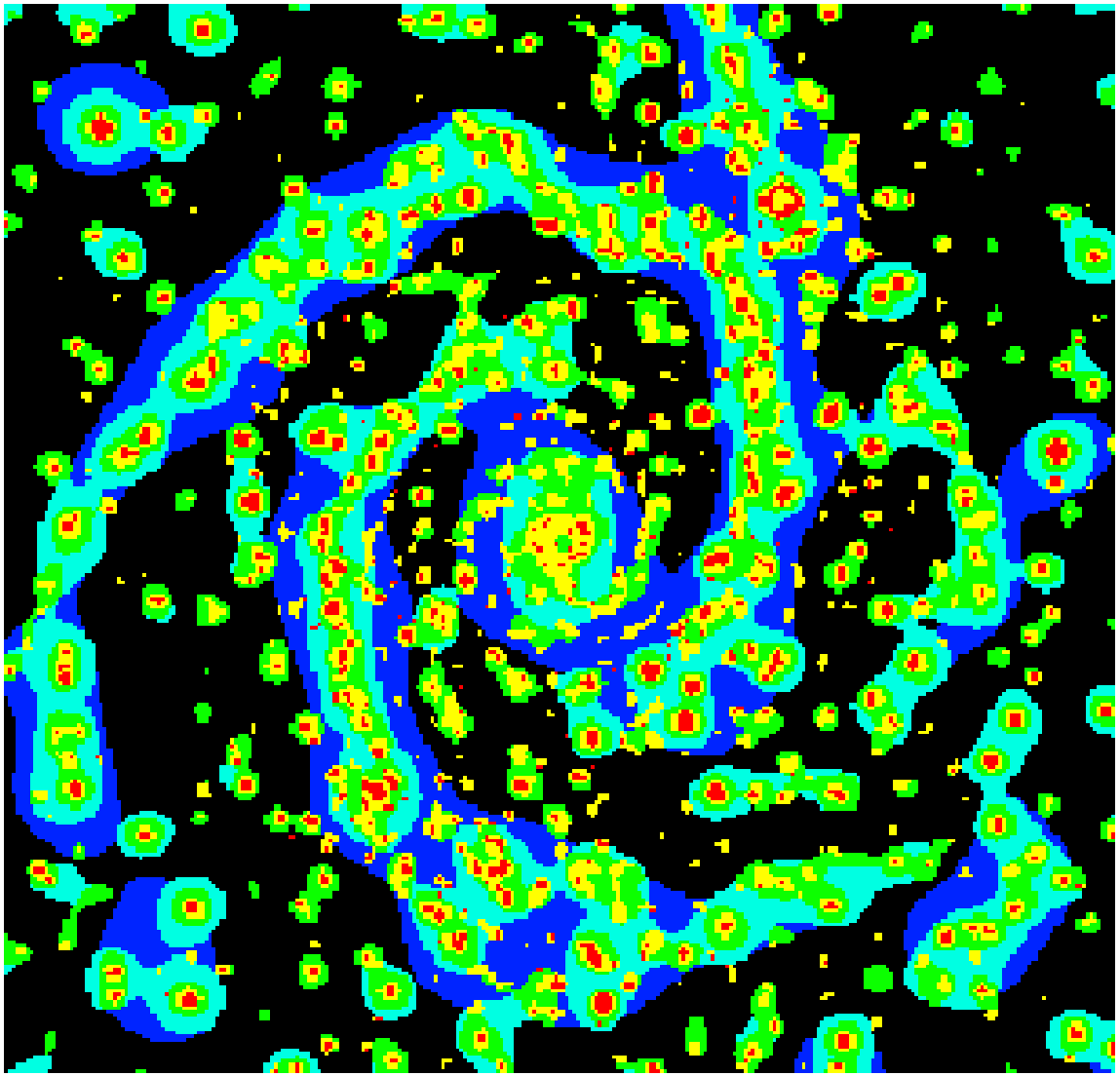
For a positive coefficient:

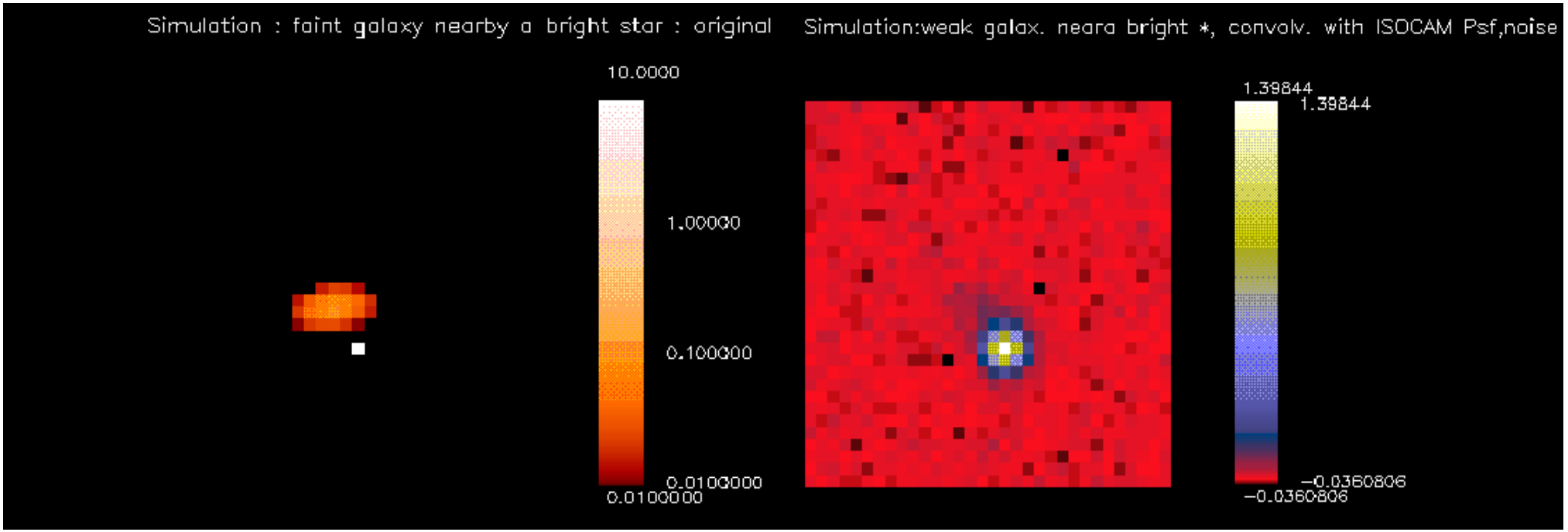
For a negative coefficient

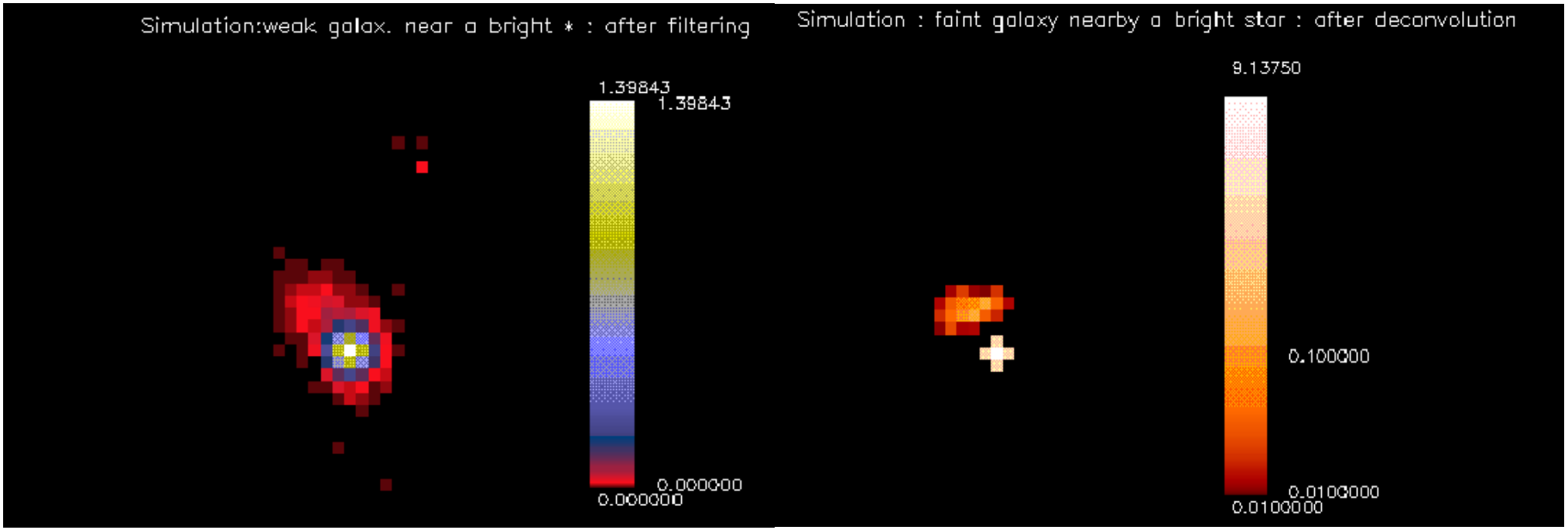


Given a threshold t, if P > t, the coefficient could be due to the noise. On the other habd, if P < t, the coefficient cannot be due to the noise, and a **significant coefficient** is detected.

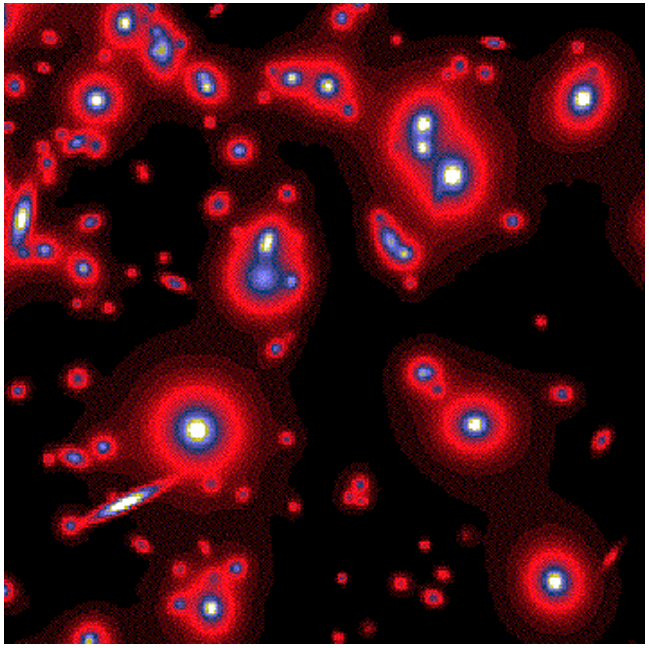
NGC2997 MULTIRESOLUTION SUPPORT

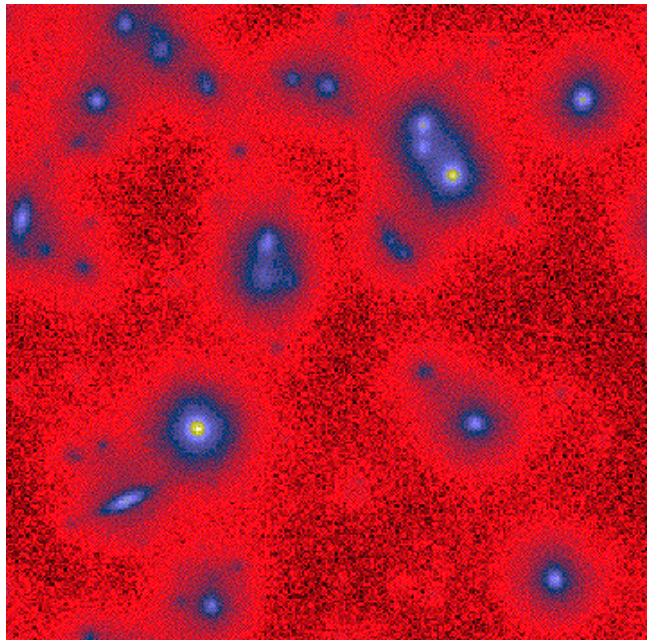


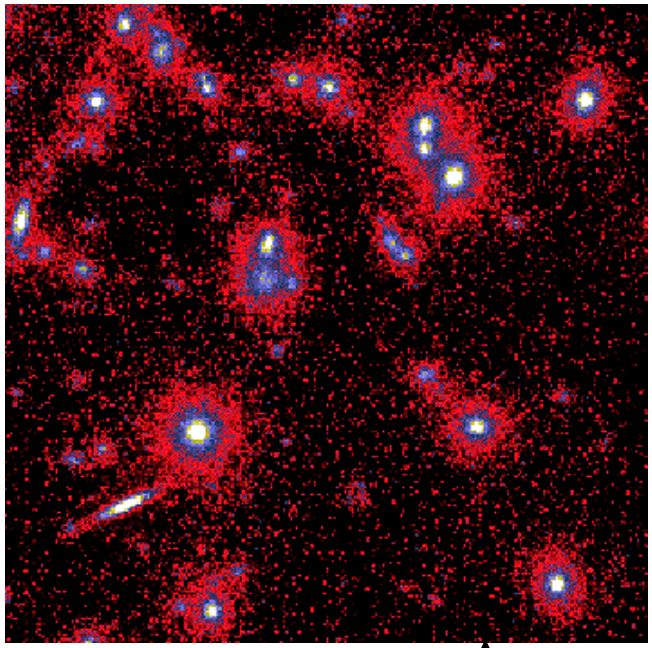

Simulation : faint galaxy nearby a bright star : original
10.0000
1.00000
0.100000
0.0100000
0.0100000
Simulation:weak galax. neara bright *, convolv. with ISOCAM Psf,noise
1.39844
1.39844
−0.0360806
−0.0360806


Simulation:weak galax. near a bright * : after filtering
1.39843
1.39843
0.000000
0.000000
Simulation : faint galaxy nearby a bright star : after deconvolution
9.13750
0.100000
0.0100000
0.0100000

DECONVOLUTION SIMULATION

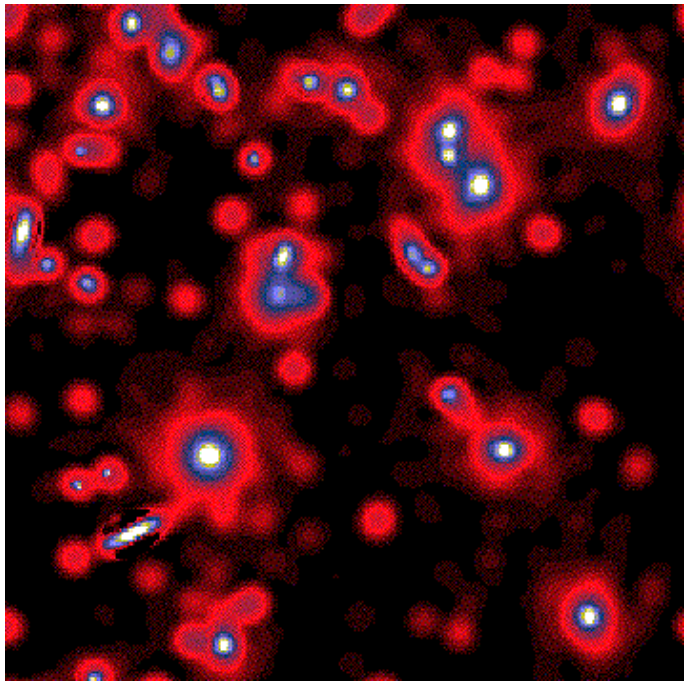


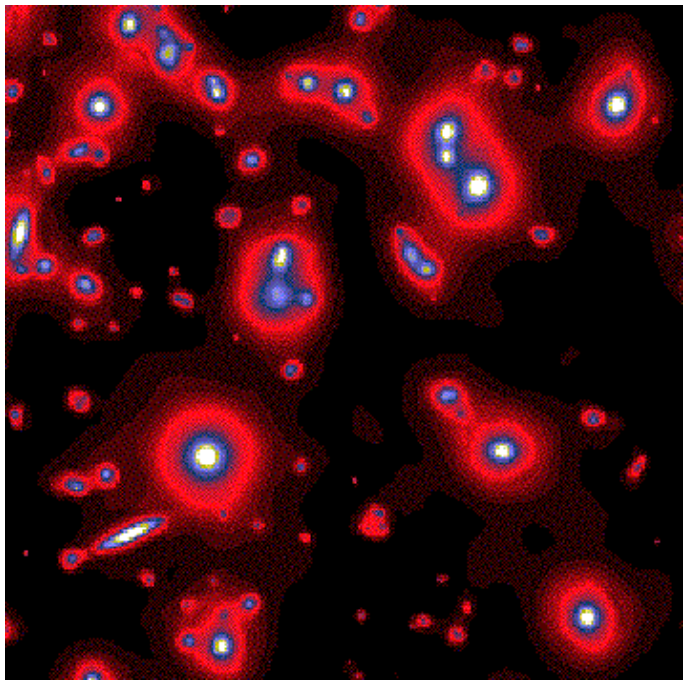




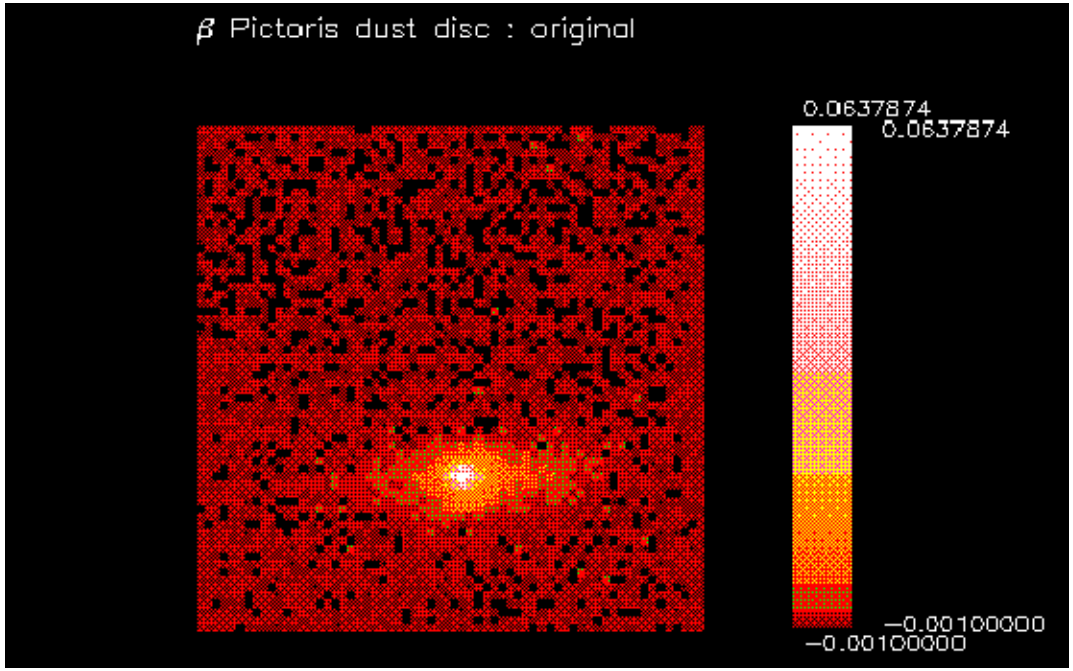
LUCY

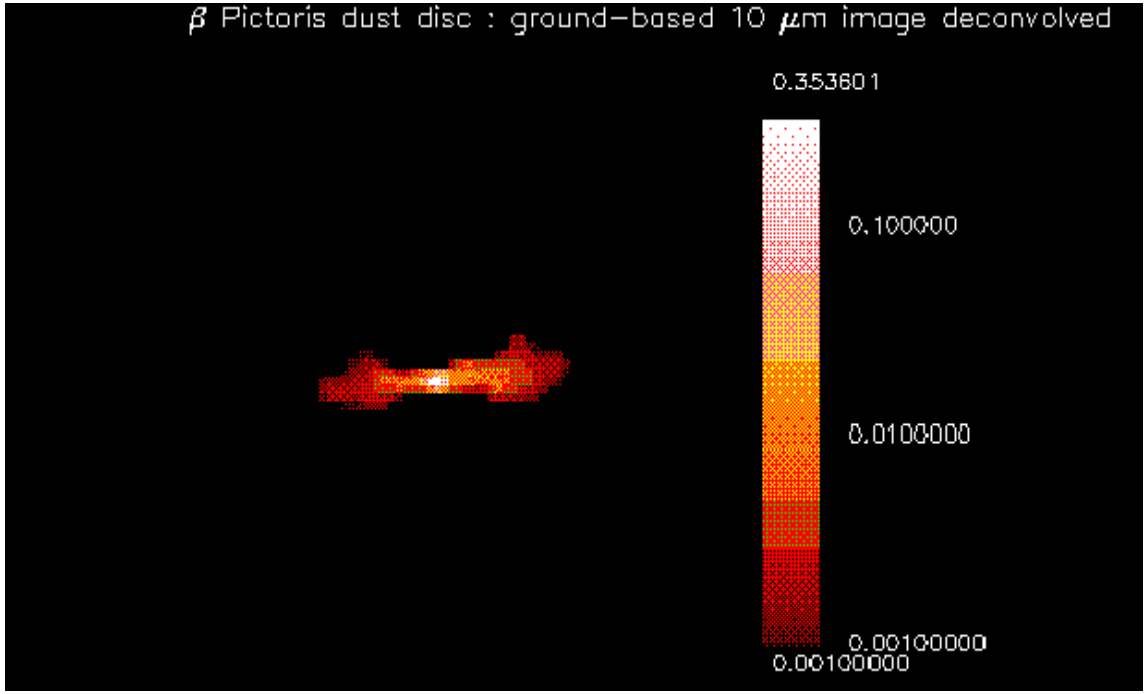
PIXON





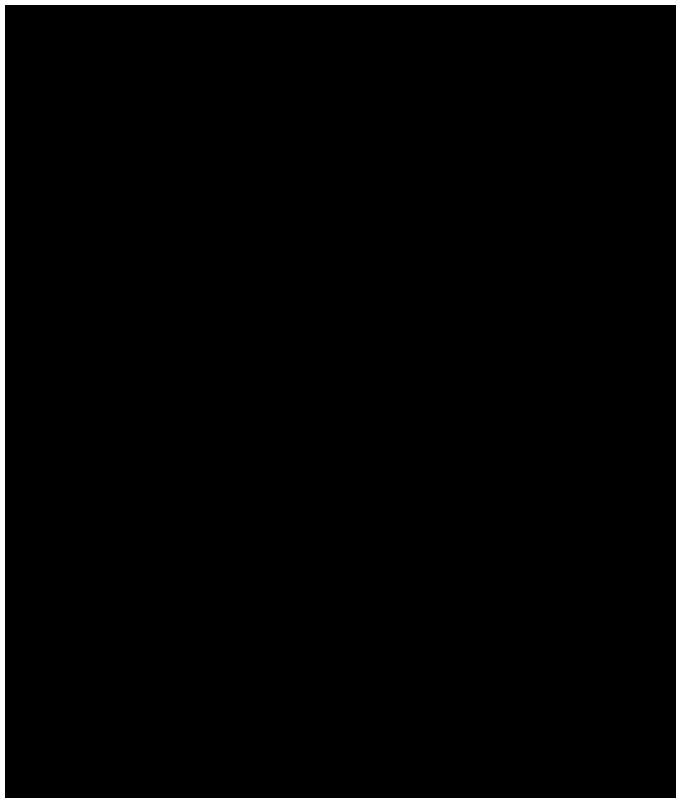
Wavelet


β Pictoris dust disc : original
0.0637874
0.0637874
−0.00100000
−0.00100000


β Pictoris dust disc : ground−based 10 μm image deconvolved
0.353601
0.100000
0.0100000
0.00100000
0.00100000

$$f = \sum_i \alpha_i \psi_i \qquad \alpha_i = \langle f, \psi_i \rangle$$

Wavelet



Curvelet