

virtual Galaxy exploration

real time, photo-realistic

November, 19 2013
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ANR veRTIGE

(RSA-Cosmos, GEPI+LERMA/ObsMeudon, INRIA)



observables:

- **fluid of stars** ($\sim 3 \cdot 10^{11}$)
 - **bulb, disc** (field stars, old), **clusters**
 - **arms** (young stars)
- **dust clouds**
 - **all-scale patterns** (filaments, bubbles)
 - **arms**
 - **HII regions** (ionised), **reflection** (blue)

imager: (\sim Hubble)

- **48 filters** (large to peak)

List of requirements:

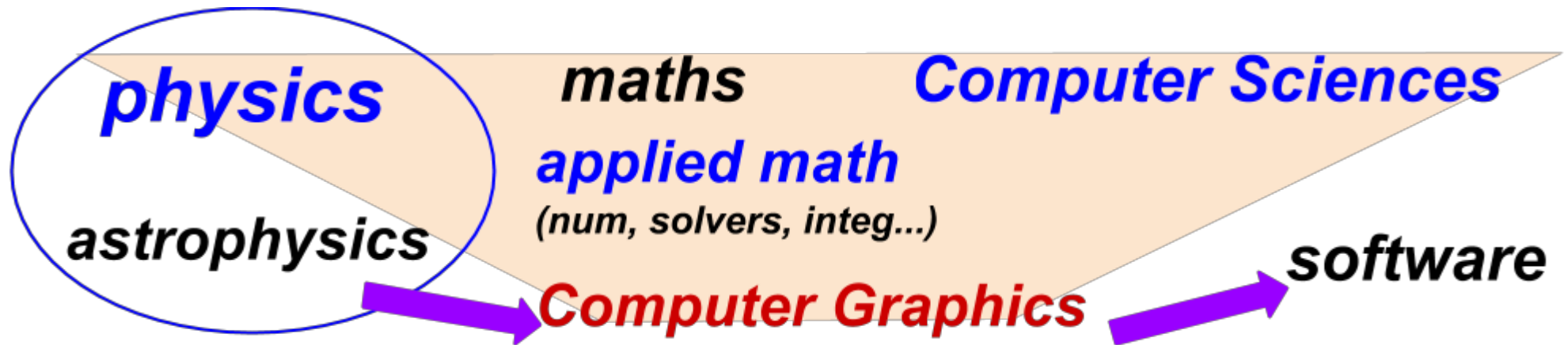
(end: dec 2014)

- ***view from far***
- ***view from inside***
- ***continuous view from earth to nearby***
- ***change imager filters***
- ***animated galaxy*** *(using GALMER SPH simulation)*
- ***amplify from astronomy statistics + ref images***
- ***photorealistic quality rendering***
- ***strong realtime on highres skydomes (planetarium)***

Some Challenges:

- **mass of data** (won't fit memory & CPU)
 - *astronomic objects*
 - *SPH simulation* (> 3×10^6 partics.)
- **all transparent** (no star-star masking!)
- **emerging phenomena: sub-scales count** (appearance filtering)
- **all spectral** (sources, extinction, scatter, ionization, filter)
- **non-linearities everywhere**
- **ranges of intensities + scales**
- **fusion of data** (amplified SPH + star catalog)
- **continuum to discreet**
- **interpolations**
- **knowledge** *from different fields, to revisit, non-complete*

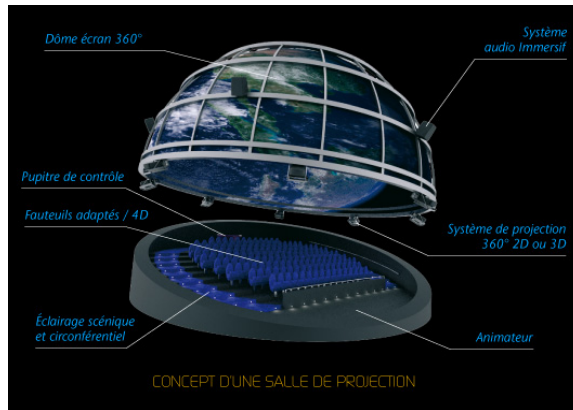
Involved fields - who we are:



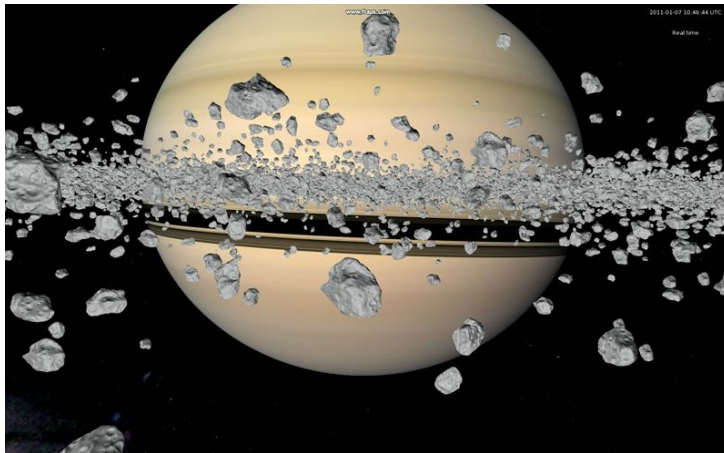
- ***RSA Cosmos (planetariums)***
- ***GEPI-LERMA (ObsPM)***
- ***Maverick (INRIA, CNRS, U-Grenoble)***

RSA Cosmos (planetariums):

- old French company



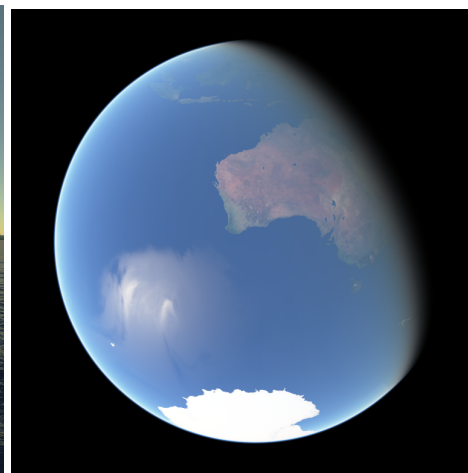
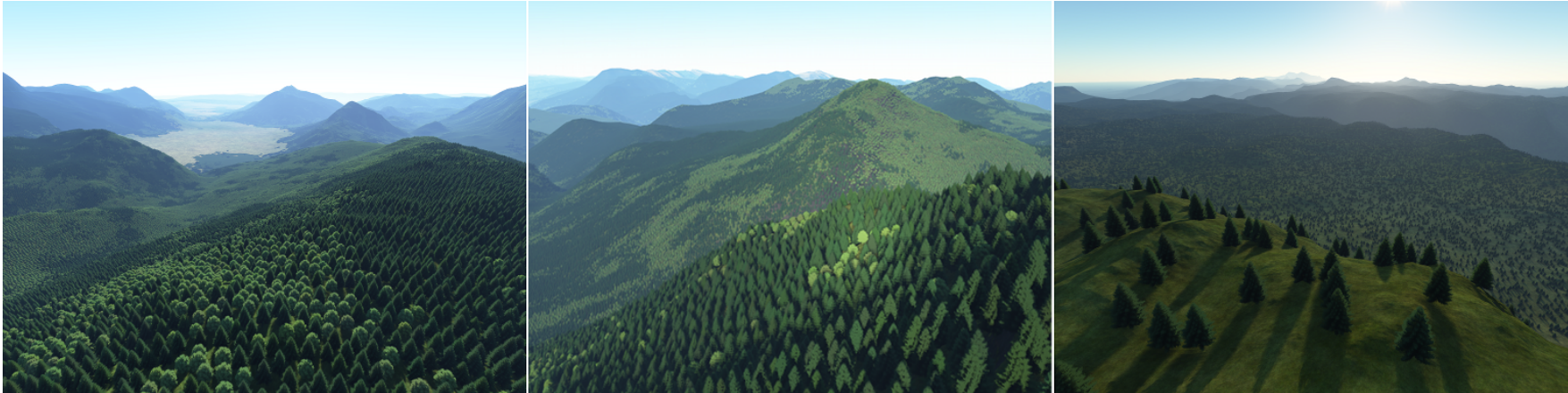
- new era of numerical planetarium



Maverick (INRIA, CNRS, U-Grenoble):

- ***Realistic real-time visualisation (“rendering”)
of ultra-huge ultra-detailed (possibly animated) scenes***

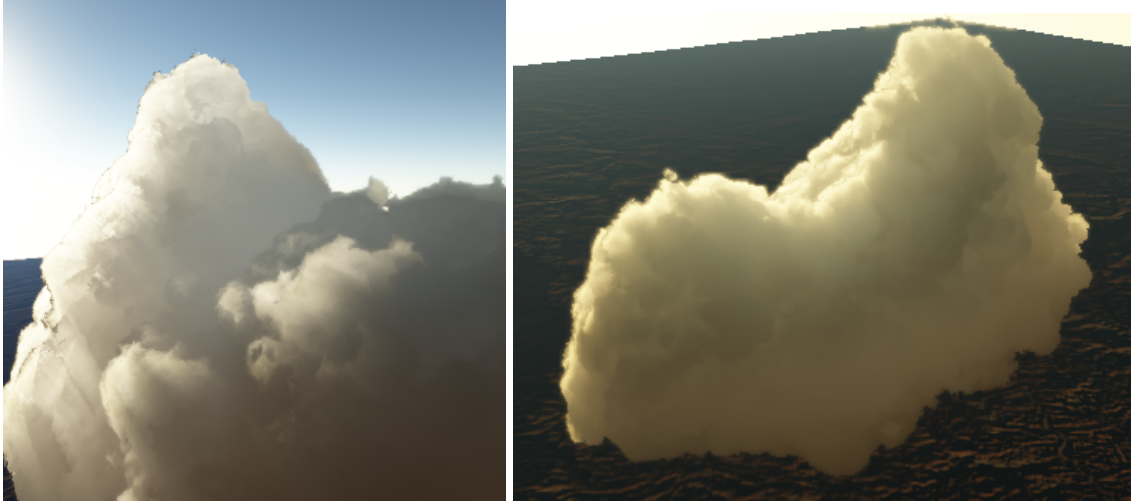
<https://www.youtube.com/user/ebruneton>



analytical integration of subscale effects

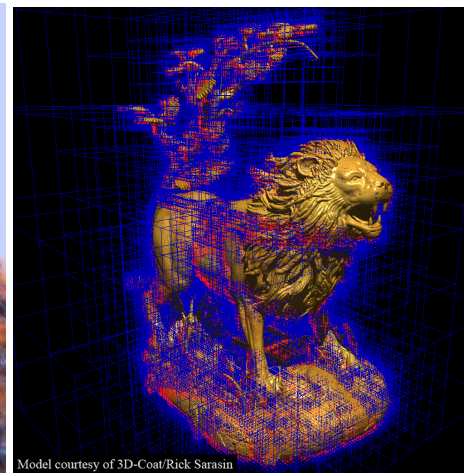
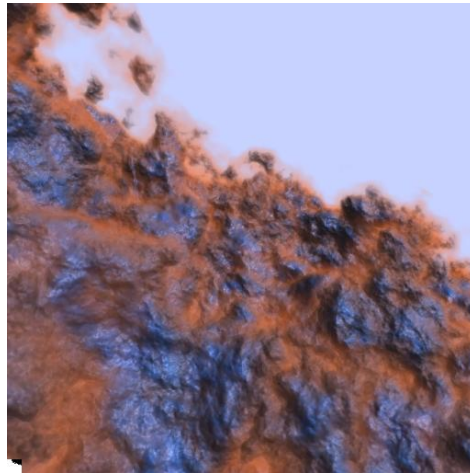
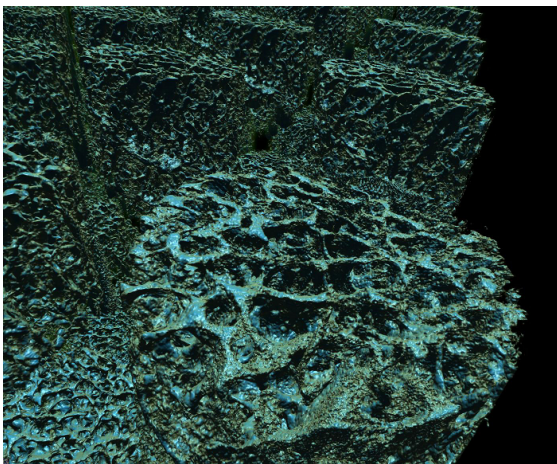
- **Real-time multiple scattering (Mie) radiative transfer (sun+sky)**

<https://www.youtube.com/channel/UCJxUBMxNYqouhFRJG5N2KIQ>



models reformulation

- **GigaVoxels** <http://maverick.inria.fr/Membres/Cyril.Crassin/index.html>



Model courtesy of 3D-Coat/Riek Sarasin

Octree of voxels, out-of-core (on demand+cache), GPU

general principles: *~right the opposite of usual scientific calculus*

- on demand, just in time, just necessary (field of view, depth, content, filters)*
- top down*
- spatial distribution + dedicated sub-grid analytical models*
- amplification, proceduralism*

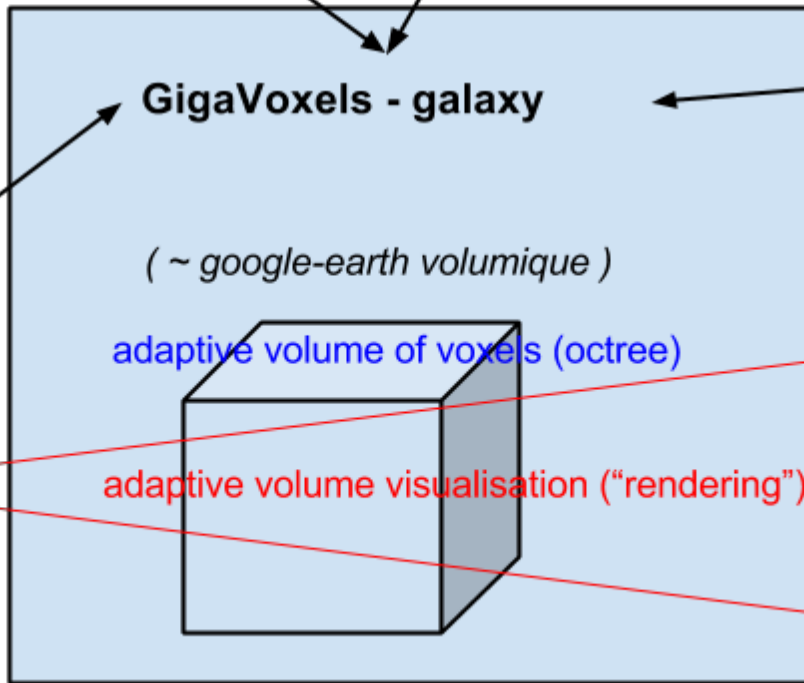
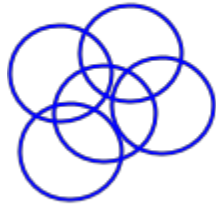
GALMER

astrophysical knowledge
models, stats, phenomenology

HR diagrams, isochrones,
IMF, ICMF
extinction, scattering
ionisation, Strömgren
Planck, star spectrums
imager, PSF
...

fields:

ρ_{stars}
 ρ_{gaz}
 Z



filters

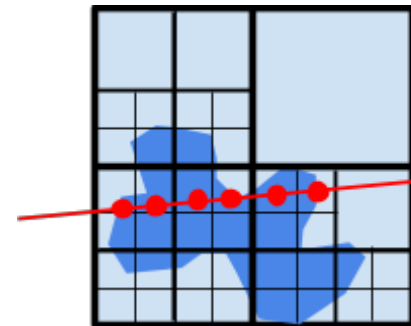
GigaVoxels - galaxy

(~ google-earth volumique)

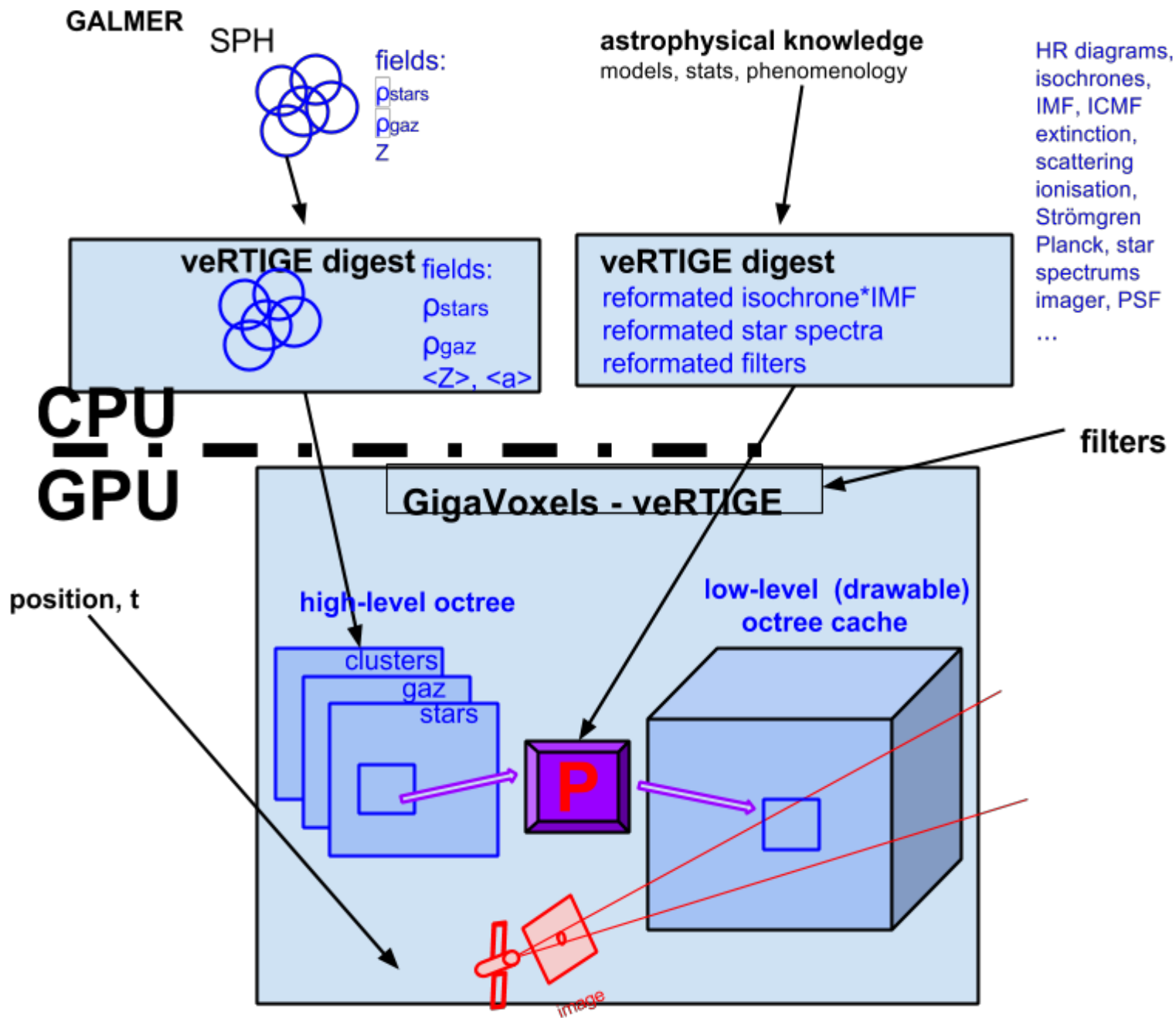
adaptive volume of voxels (octree)

adaptive volume visualisation ("rendering")

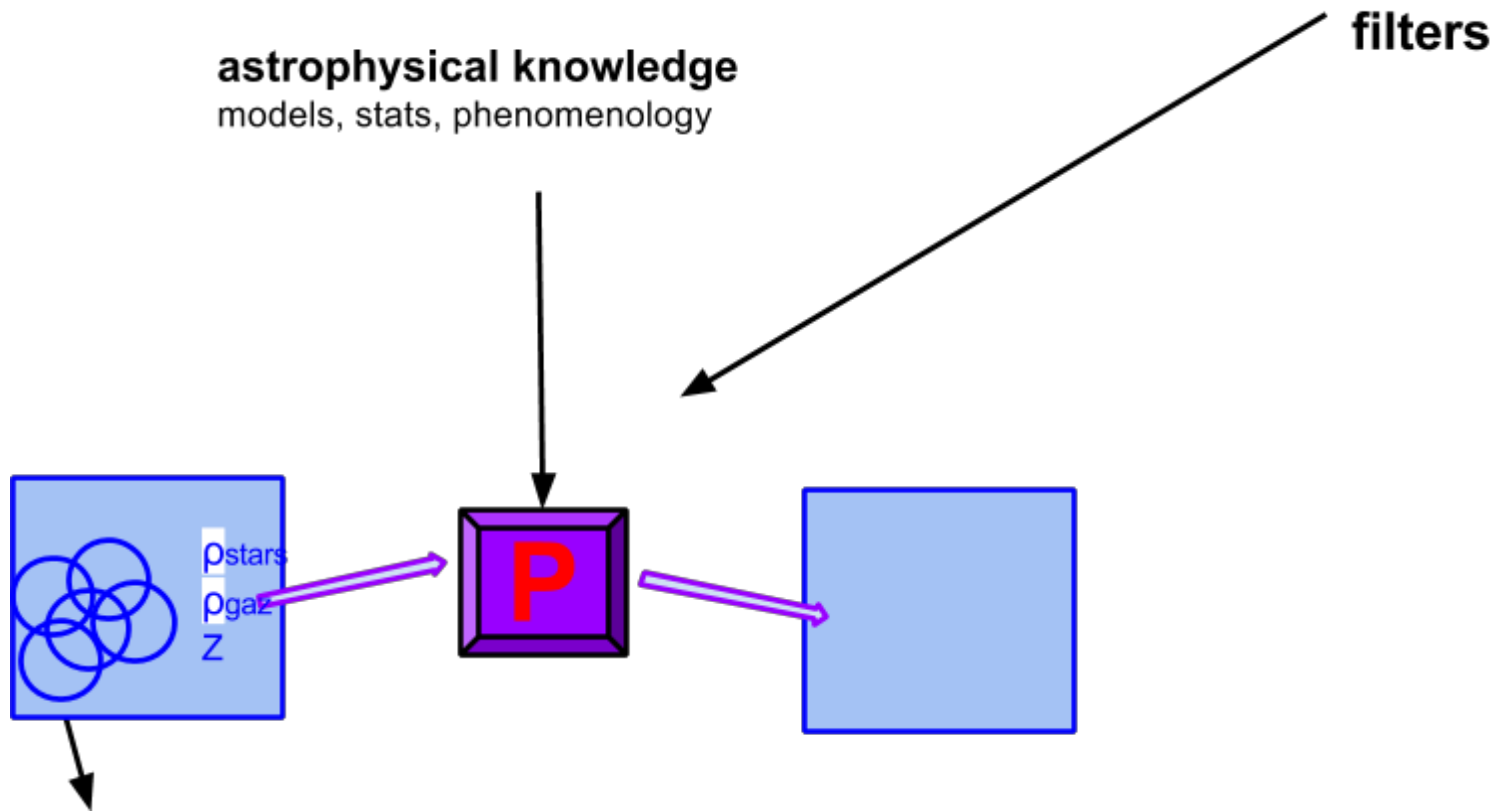
image



$$L+ = T^* L_{\text{loc}}$$
$$T^* = T_{\text{loc}}$$



Producer:



Tools:Addressing some challenges

1: Spectral aspects

- **a priori knowledge**

⚠ *lin vs log vs log-log* ; λ vs $\frac{1}{\lambda}$ vs f ; **MKSA vs**
 “column/ V_{sun} ”

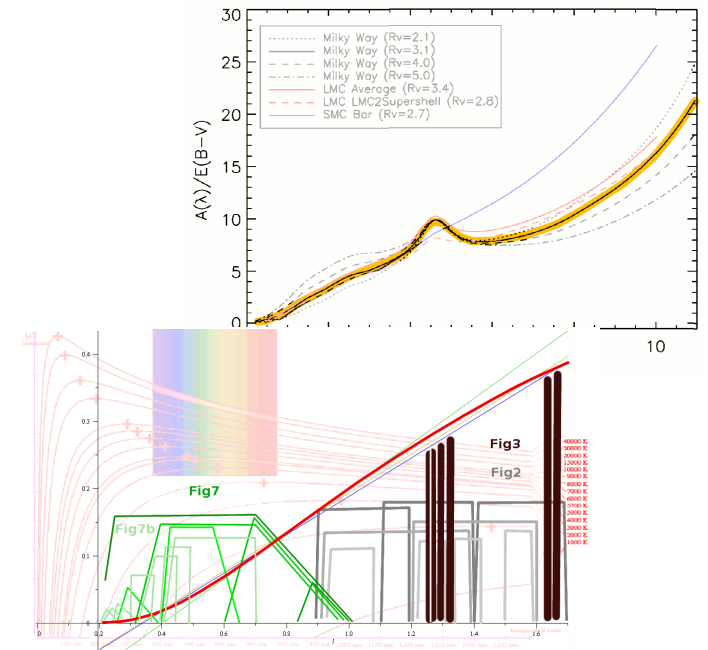
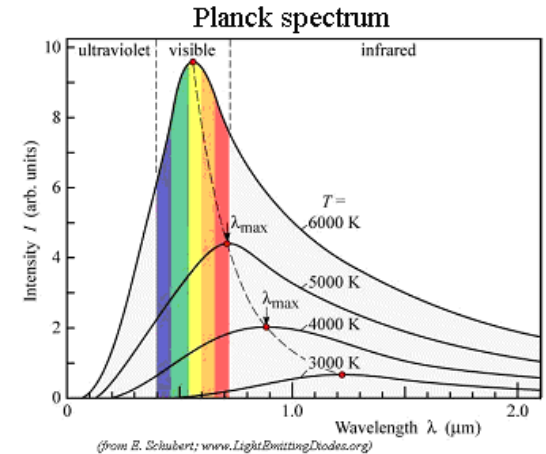
- **filters known at run time**
in filter window; proj on func base

- **peaks:** separately, if needed
- **Filter weight:** P_0 or P_1
- **Source:** $\sim P_1$ to P_3
- **Extinction:** $e^{-\frac{cst}{\lambda}}$; $\sim P_1$ or P_2

→ **F.S.E** : P_n or $P_n \cdot e^{-f(\lambda)}$

- **store + render coefs (not spectra)**

- \int_{λ} easy



2: Filtering & LOD

not 1 star, but:

- **star mixture in pixels/voxels**

$$\int_{xyz} \rho(xyz) \int_m \int_{p'} \int_{f \in \text{filtre}} W(f) \langle I.S_{BB} \rangle (f, LTr_{(m(p'); a(z,p'), Z(xyz))}) df dp' dP_{IMF}(m) d_{xyz}$$

in facts,

- **star + gaz extinct mixture**
- “ “ + **emissions mixture**
- “ “ “ + **inhomogeneous gaz (so long ‘density’)**
- “ “ “ “ + **gaz-star correlation**

amplification and noise

SPH simu: recons = smooth fields

- ***density continuum fluctuations***
- ***continuum to discreet (clusters of clusters, clusters, stars)***

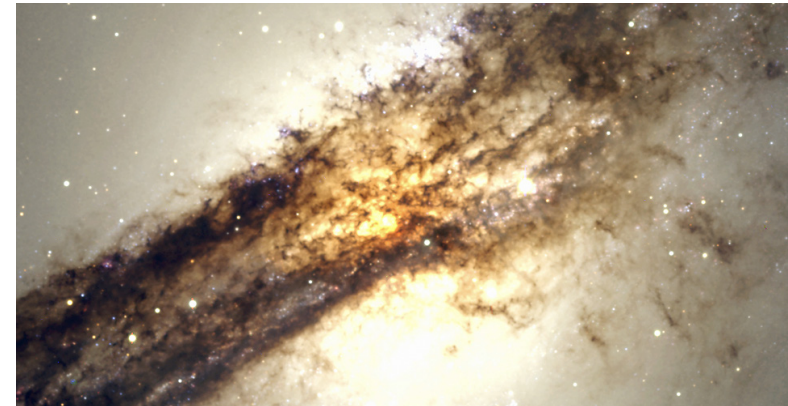
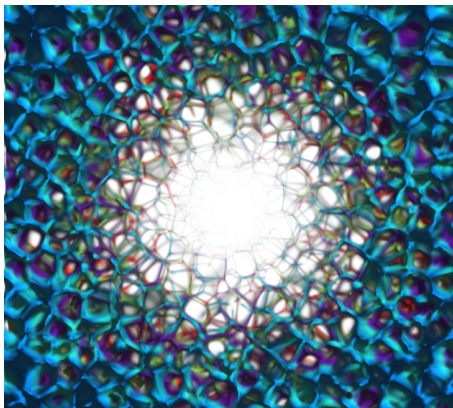
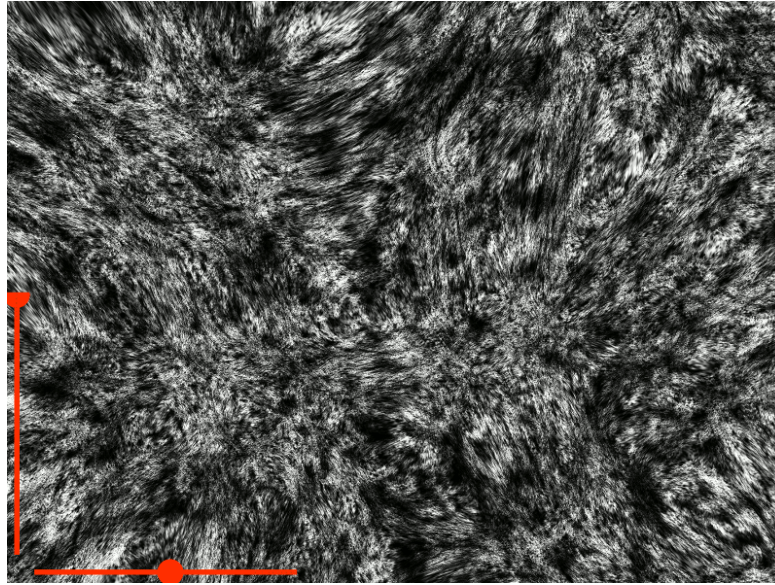
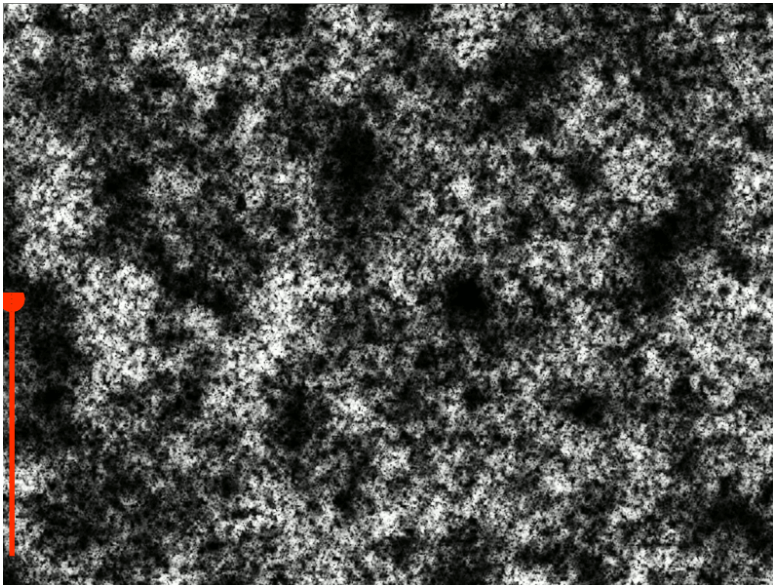
Dust clouds

- ***fractal, on large range of scales***
- ***features at all scales (cloud, arms, plumes...)***
- ***anisotropy***
- ***shaped by stars (shockwaves, ionization, SN)***

hierarchical autogravity collaps

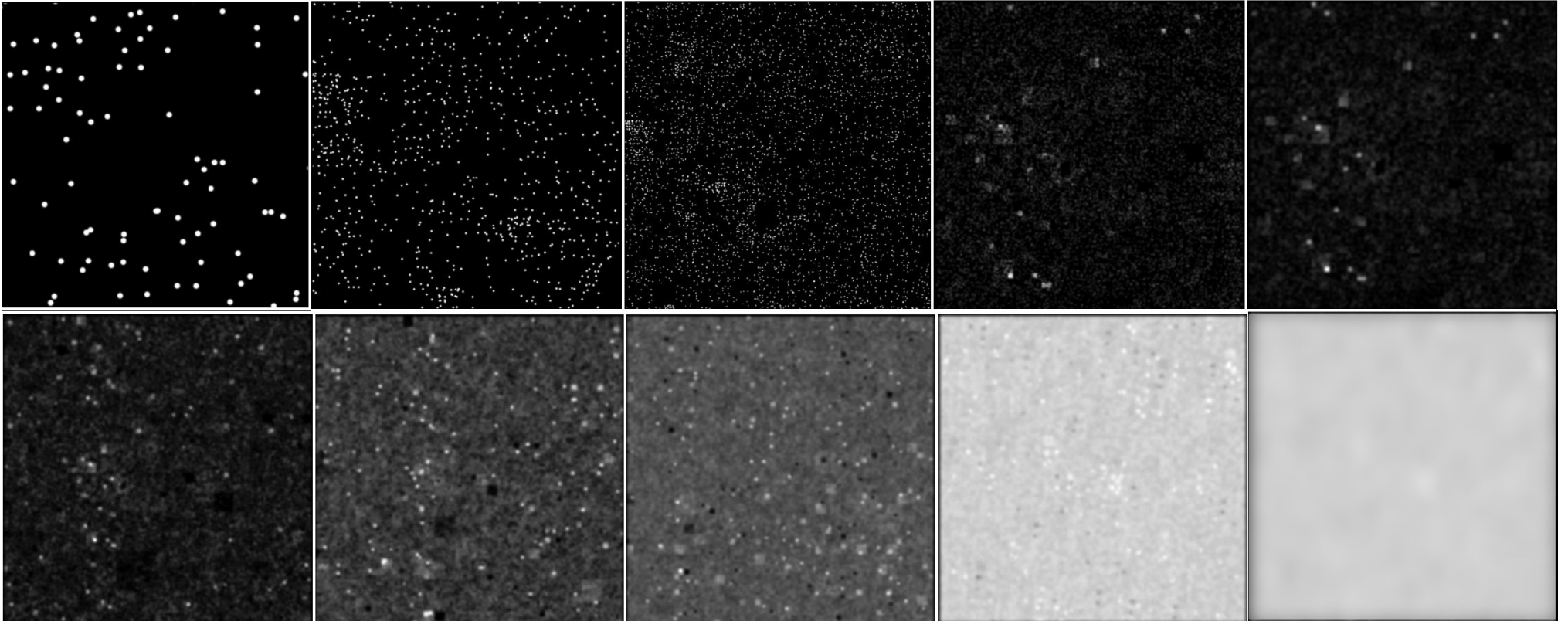
→ **not fractal; multifractal**

→ **not Perlin- Σ ; Perlin- Π : $\Pi(1 + k \cdot sBaseNoise(warp(2^i x)))$**



Eulerian Poisson noise:

recursive top-down intervals



What is still missing

