Orbital integration of Local Group dwarf galaxies: the Carina dwarf example

By **S. Pasetto**

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Why to study LG dwarf galaxies?

- *Interacting* *low-mass* *DM-dominated* satellites
- *Local* satellites
- Cocktail of *internal* & *external* dissipative phenomena

Or

- Pretty massive (e.g. Mag. Clouds),
- Isolated (quiescent evolution)
- DM-free (e.g. Tidal dwarf galaxies)

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Why Carina dwarf?

- Challenging SFH scenario

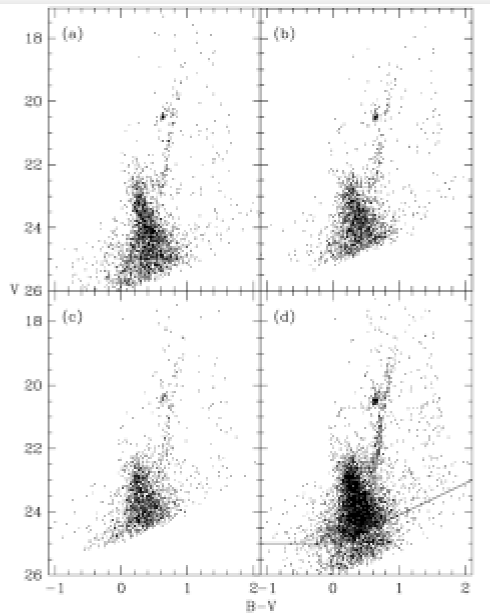


Fig. 6.—CMDs for the three fields observed in Carina: (a) field 1, (b) field 2, (c) field 3, (d) all three fields combined. The solid line represents the limiting magnitude of the shallowest field, field 3.

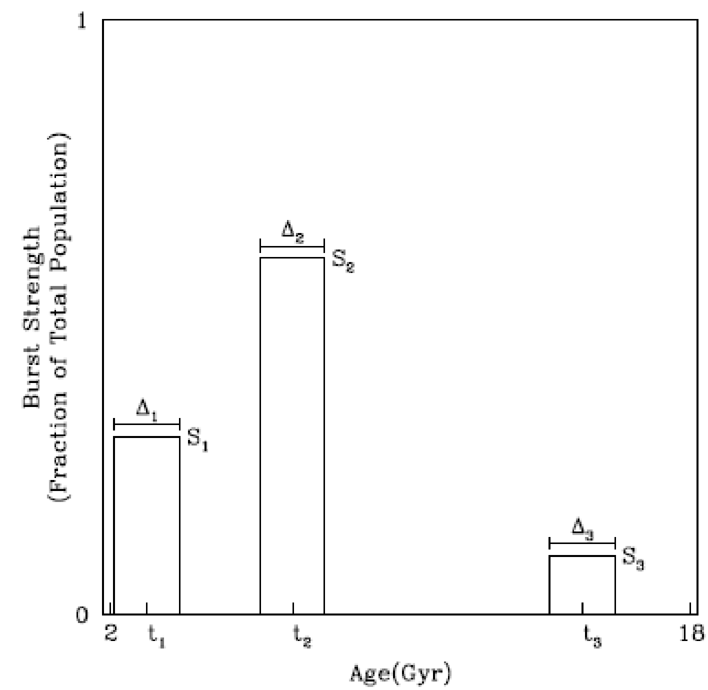


Fig. 13.—Parameterization of Carina's star formation history. We assumed three major episodes of star formation: t_i is the age of the episode in Gyr, Δ_i is the duration of the episode in Gyr, and S_i is the strength of the episode in a fraction of the total population. For reasons explained in the text, t_1, t_3, and Δ_3 are fixed at 3, 15, and 1 Gyr, respectively.

From Mould & Aaronson (1983) to Fabrizio+ (2011)

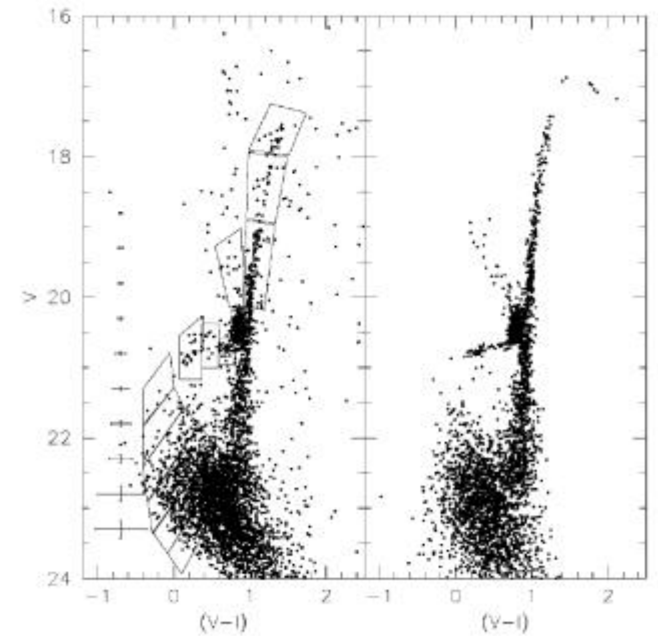


FIG. 1.—Comparison of the observed and synthetic CMDs for Carina. The left panel shows the statistically decontaminated CMD of the central region of Carina, along with the boxes used by the χ^2-minimization technique. The right panel shows the simulated CMD, assuming the PT law described in the text.

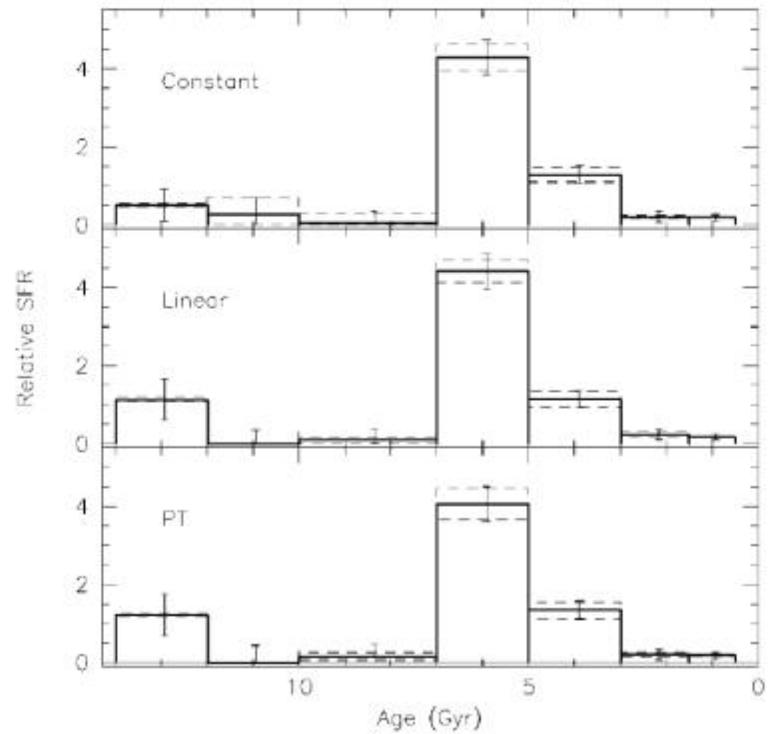
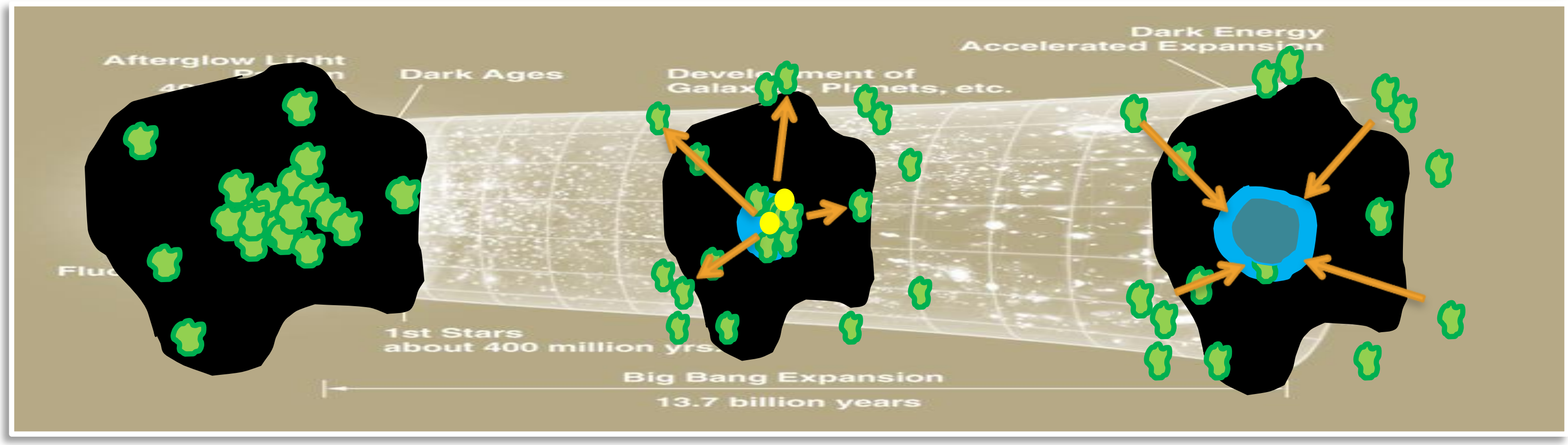
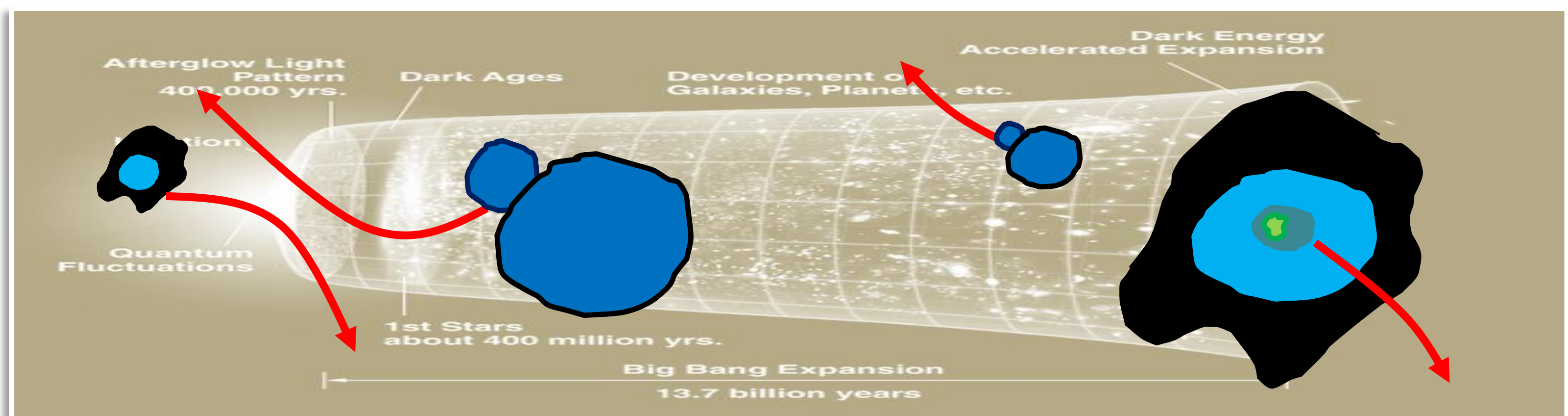


FIG. 3.—Relative SFH for the central region of Carina. The rates are normalized to a lifetime average rate of 25.6 $M_{\odot}$ Myr^{-1}. The error bars represent 3 σ confidence intervals from the χ^2-statistic; the dashed lines show the upper and lower limits to the SFH derived from 100 repeat CMD simulations. The bulk of the star formation appears to have happened in a long episode between ~3 and ~7 Gyr ago.

Rizzi+ 2003

Already investigated solutions...





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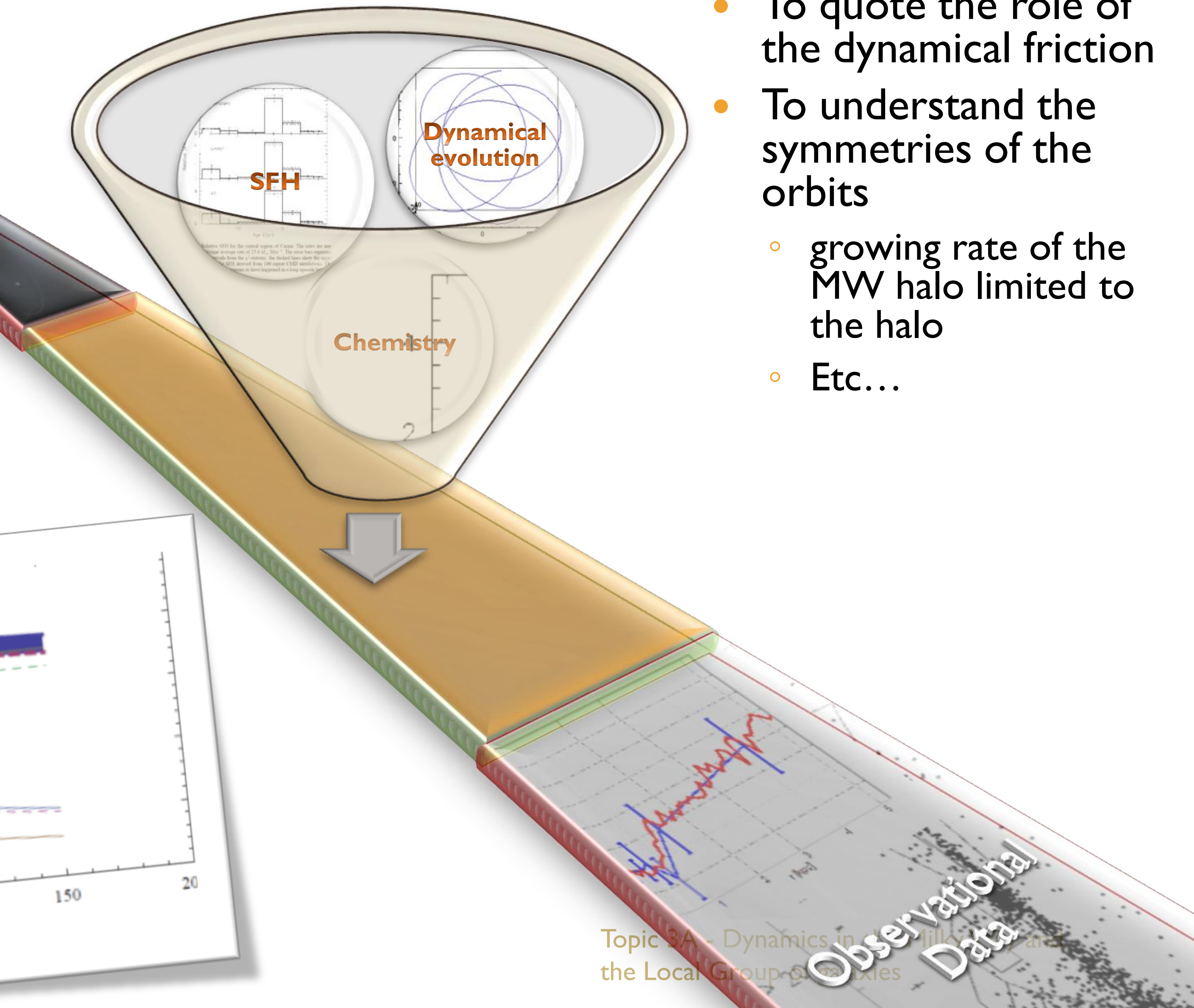
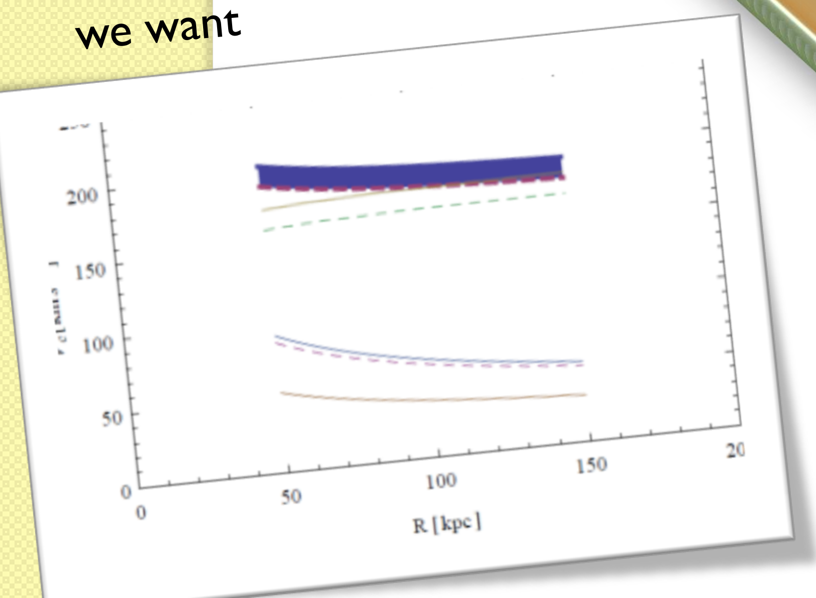
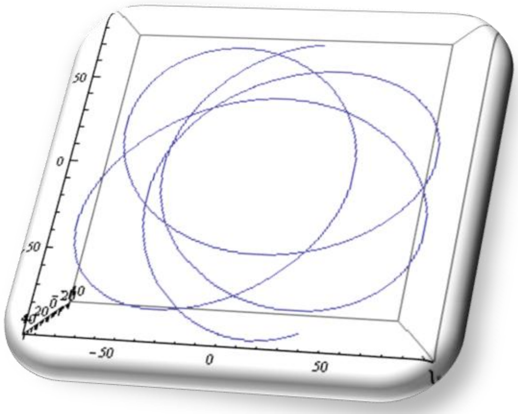
INGREDIENTS

- Determine the $\Gamma(T_0)$ allowed to the N-body simulations
- To quote the role of the dynamical friction
- To understand the symmetries of the orbits
  - growing rate of the MW halo limited to the halo
  - Etc…



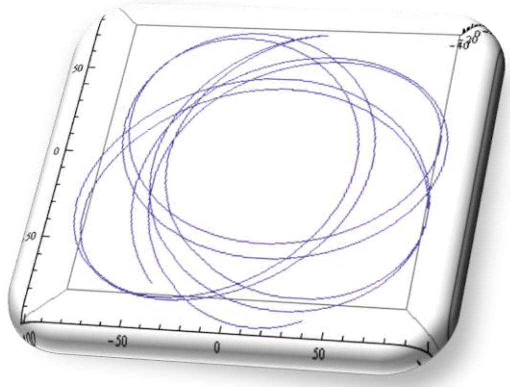
MW growing external potential we want



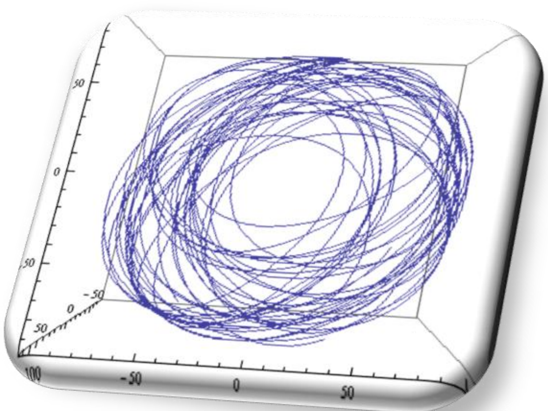


1 Orbit…

2 Orbits…



A lot of orbits…



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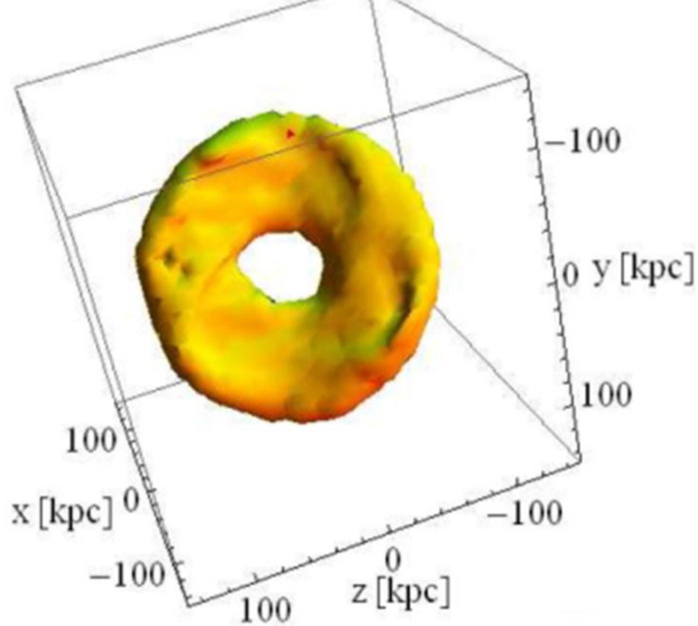
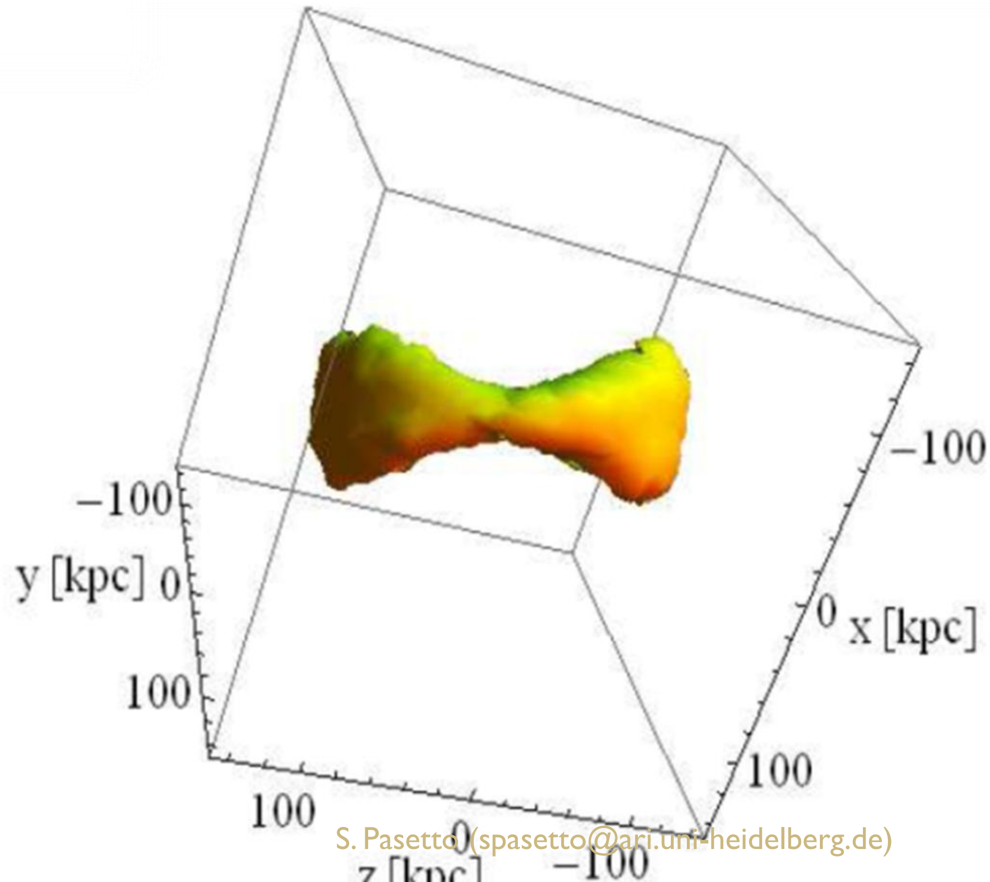
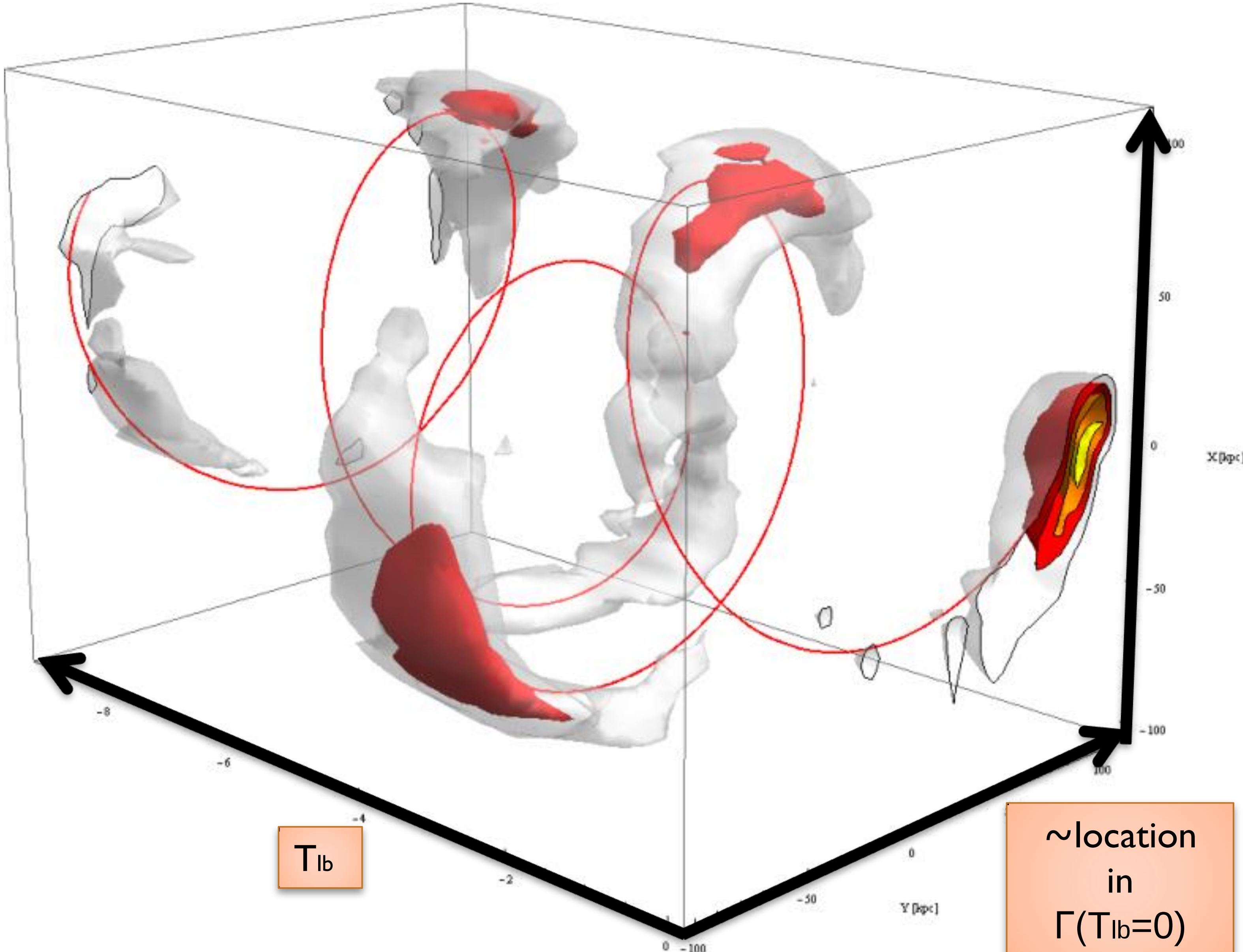

−100
0 y [kpc]
100
100
x [kpc] 0
−100
100
0
z [kpc]
−100


−100
y [kpc] 0
100
−100
0 x [kpc]
100
100
0
z [kpc]
−100



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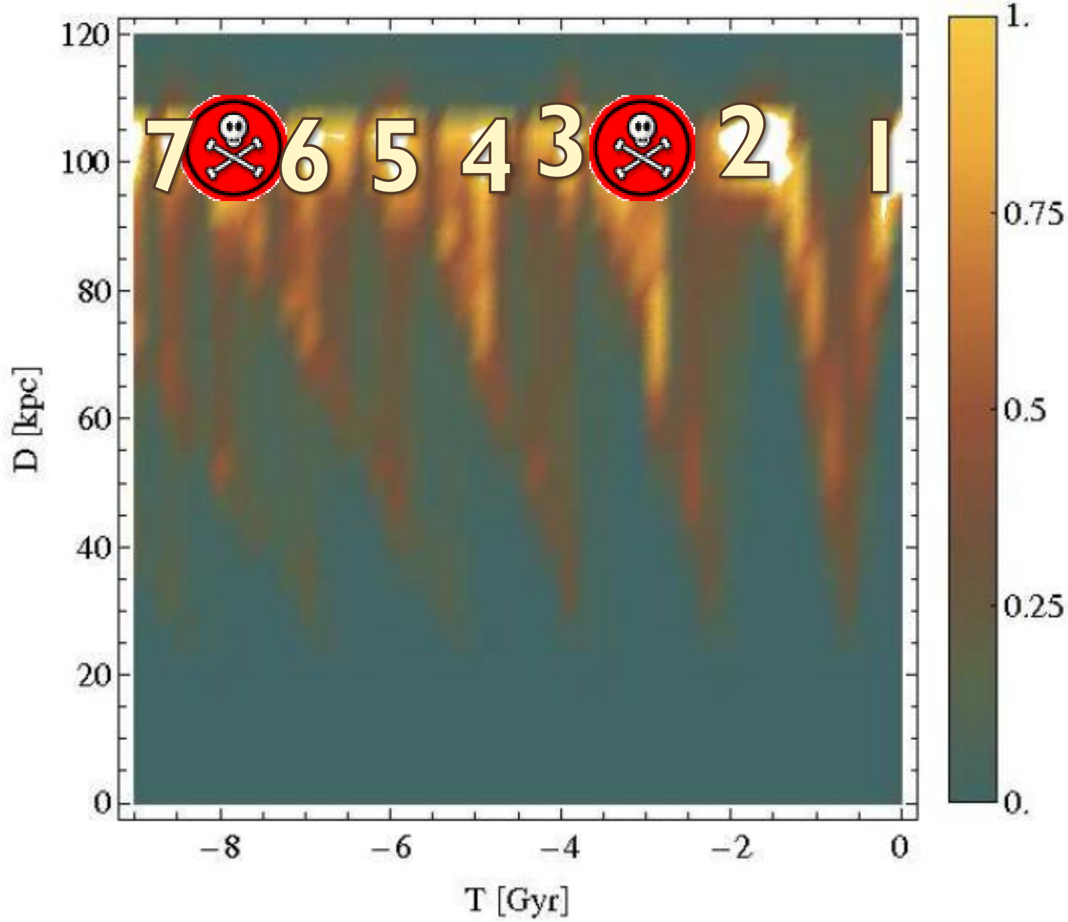
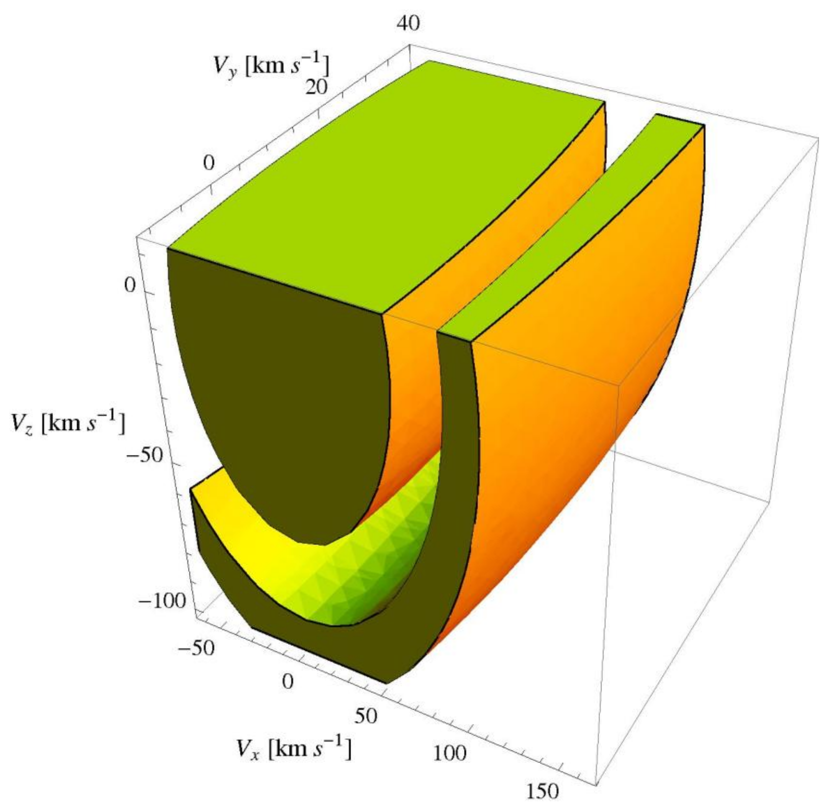


7
6
5
4
3
2
1
120
100
80
60
40
20
0
D [kpc]
−8
−6
−4
−2
0
T [Gyr]
1.
0.75
0.5
0.25
0.

SFH as constraint for the orbit by minimizing the action

$$L = \frac{1}{2} m_{\mathrm{Car}}(t) \left\|\dot{\mathbf{x}}(t)\right\|^2 - m_{\mathrm{Car}}(t)\, \Phi_{\mathrm{Gal}}(\mathbf{x}, t)$$



$$S \equiv \delta \int_{t_0}^{0} L\, dt$$

$$\partial_t d(t, v_0)\big|_{t=\hat{t}} = 0 \wedge \partial_{t,t} d(t, v_0)\big|_{t=\hat{t}} > 0$$

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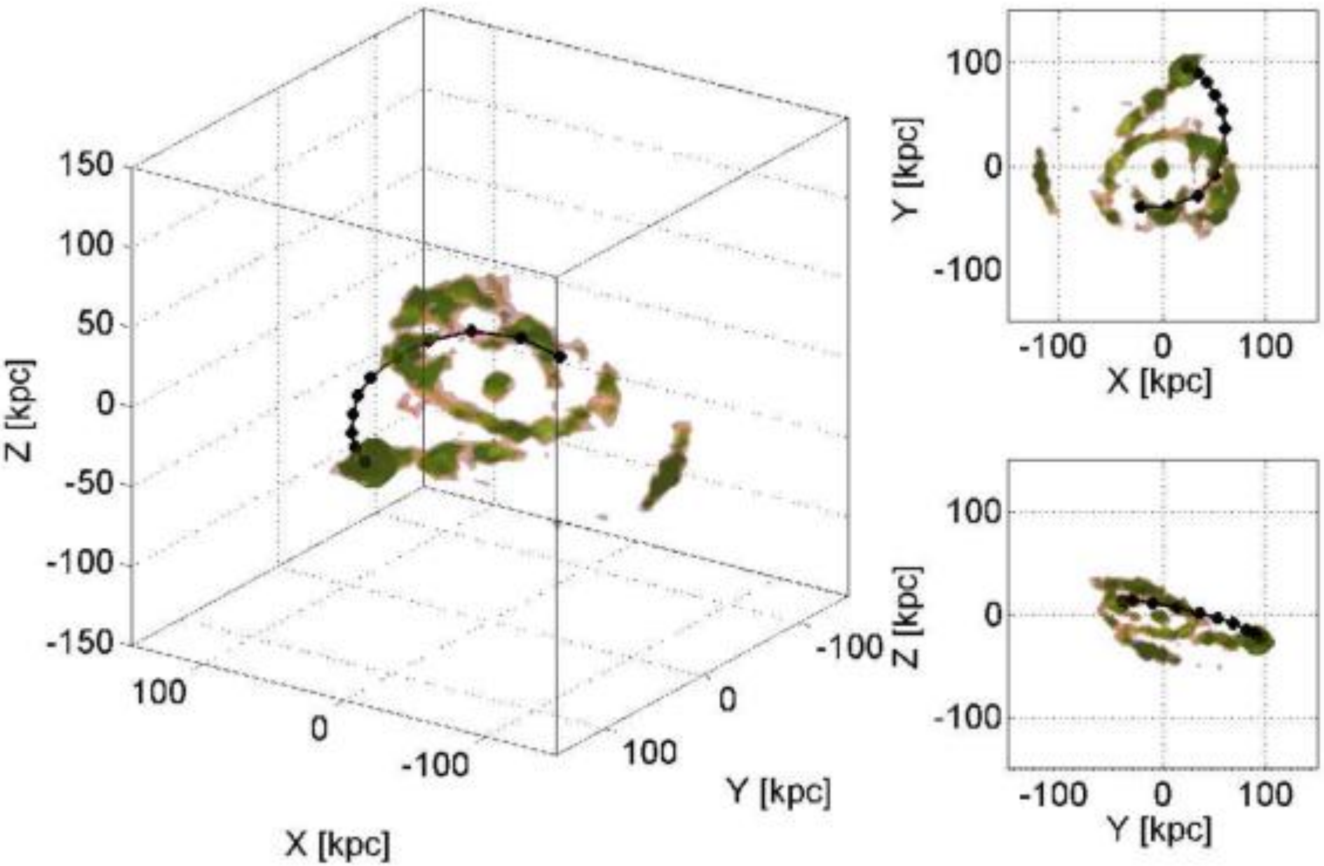
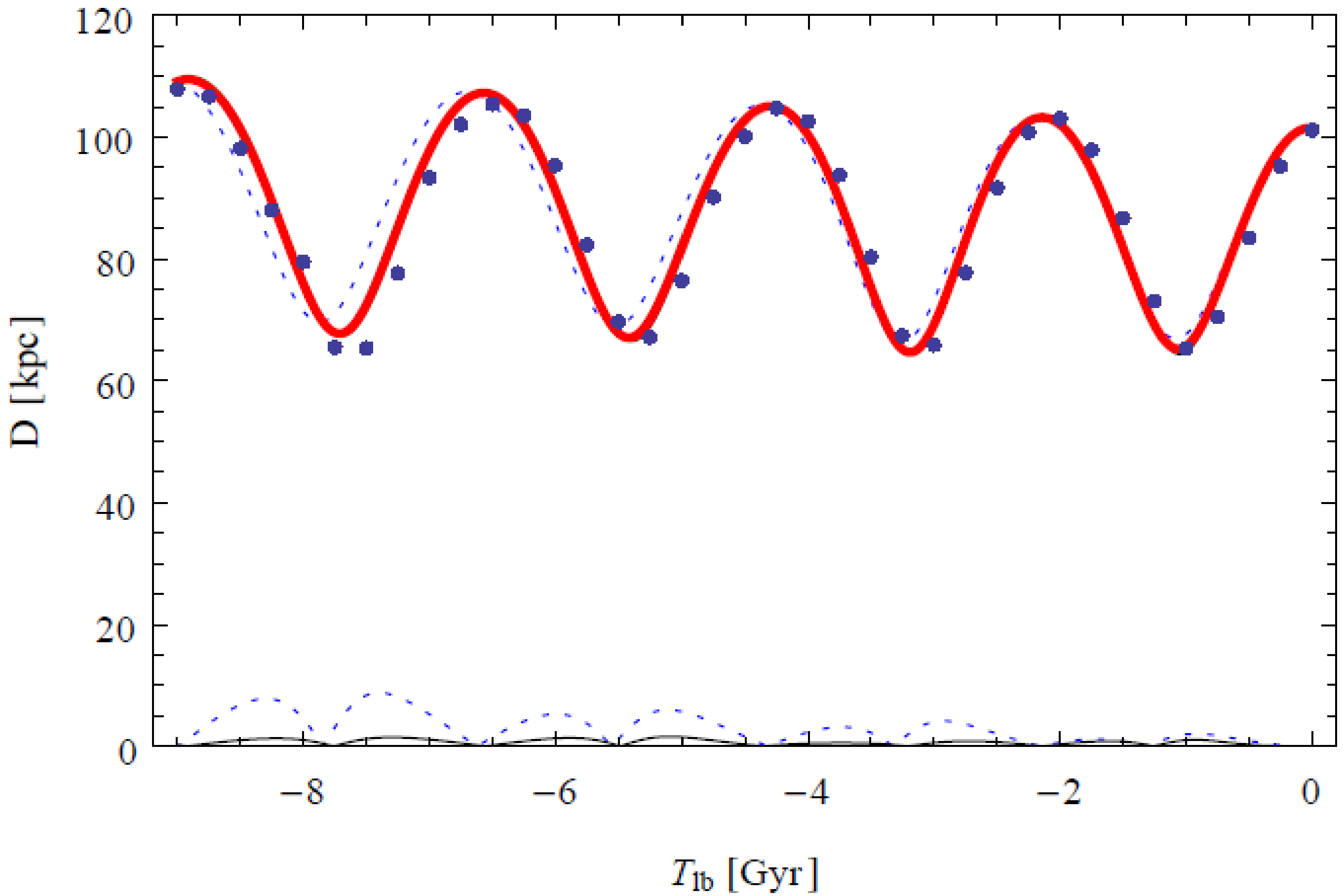
A more complex exercise: chemo-dynamics N-body sim.



Check on the point-mass integration



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When pointmass integrations are good?

$$m_I^{Car}\frac{d^2\mathbf{x}}{dt^2} = -m_G^{Car}\nabla_{\mathbf{x}}\Phi_{MW}(\mathbf{x}) = -\int \rho_G^{Car}(\mathbf{x}')\nabla_{\mathbf{x}'}\Phi_{MW}(\mathbf{x}')\,d^3\mathbf{x}'$$

…iff the gradient of the external potential is constant.

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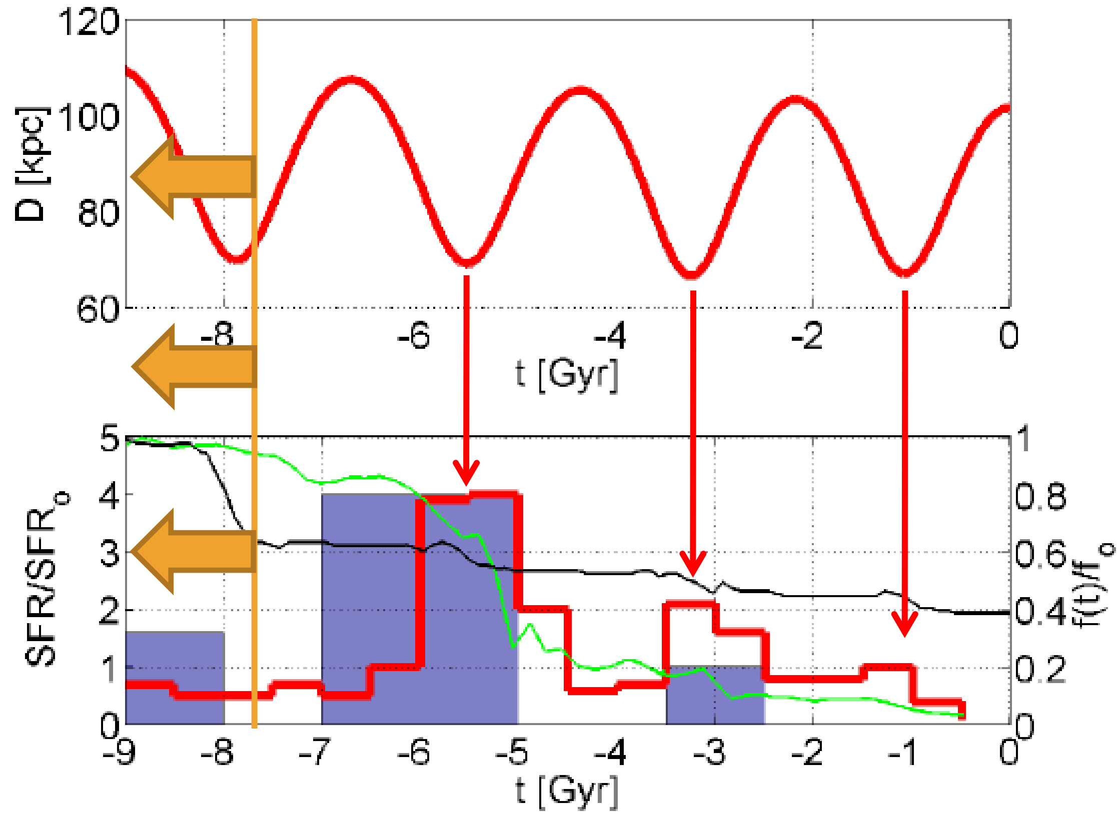
New solution for the SFH: SF events can be triggered by pericenter passages:



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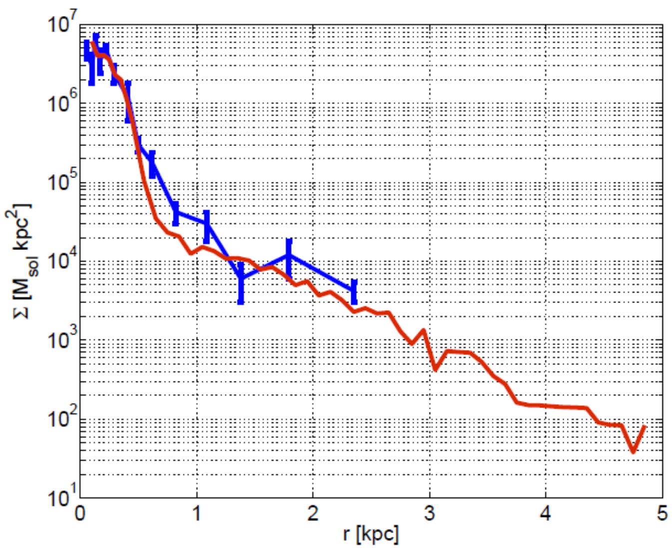
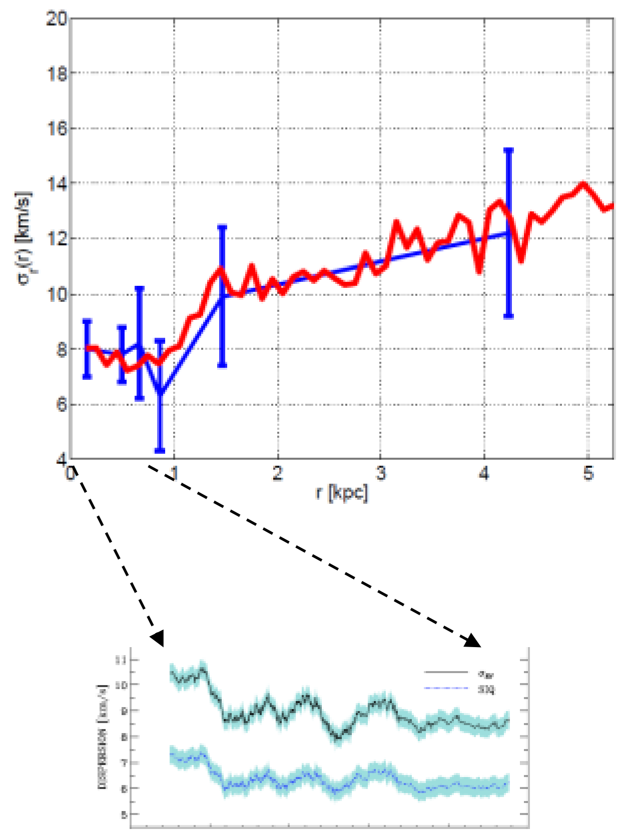
Stellar component is compatible with the observations

Surface density



l.o.s. velocity dispersion



	$t_{lb} = t_0$	$t_{lb} = 0$
l		$\cong 260$ [deg]
b		$\cong -22$ [deg]
d		$\cong 100$ [kpc]
$V_{l.o.s.}$		$\cong 219$ $[kms^{-1}]$
$M_{\rm gas}$	free parameter	$\cong 0$
$M_{\rm star}$	$1.998 \times 10^7 \mathrm{M}_\odot$	$\cong 1.9 \times 10^6 \mathrm{M}_\odot$
$M_{\rm dark}$	$1.978 \times 10^8 \mathrm{M}_\odot$	$0.675 \times 10^8 \mathrm{M}_\odot$

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Conclusions:

- **Constrains on the orbits from the star formation with the minimum action principle**
- **Interpretation of the point mass integration**
- **New scenario for Carina dwarf galaxy SFH**
- **Full N-body simulation recover the observational data (but see to Fabrizio+ (2011)).**

References: Pasetto S. et al 2011