The Distribution of Supernovae Relative to Spiral Arms of Host Disc Galaxies

L. S. Aramyan,[1] A. A. Hakobyan,[1] A. R. Petrosian,[1] V. de Lapparent,[2] E. Bertin,[2] G. A. Mamon,[2] D. Kunth,[2] T. A. Nazaryan,[1] V. Adibekyan,[3] and M. Turatto[4]

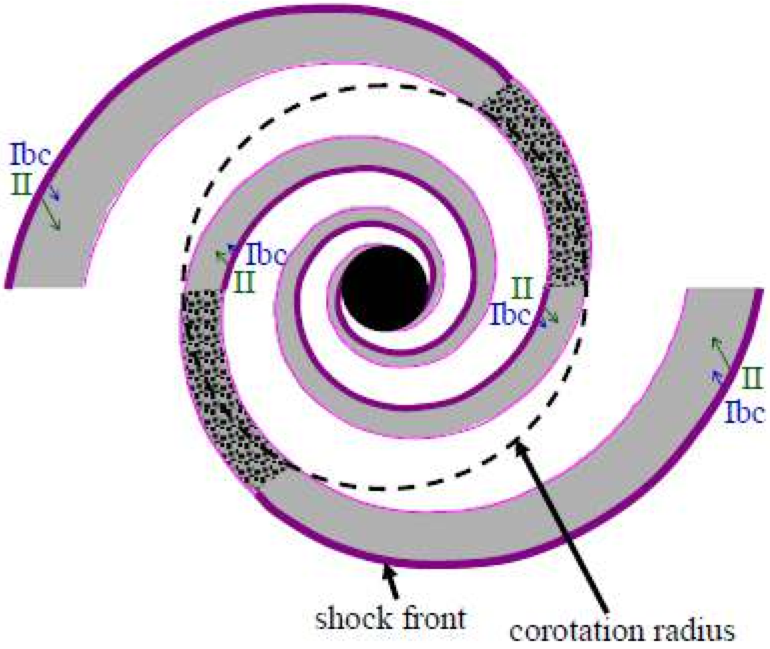
[1]*Byurakan Astrophysical Observatory, Byurakan, Armenia;*
`aramyan@bao.sci.am`
`hakobyan@bao.sci.am`
[2]*Institut d'Astrophysique de Paris, Paris, France;*
[3]*Instituto de Astrofísica e Ciência do Espaço, Porto, Portugal;*
[4]*Osservatorio Astronomico di Padova, Padova, Italy*

Abstract. Using a sample of 215 supernovae (SNe), we analyse their positions relative to the spiral arms of their host galaxies, distinguishing grand-design (GD) spirals from non-GD (NGD) galaxies. Our results suggest that shocks in spiral arms of GD galaxies trigger star formation in the leading edges of arms affecting the distributions of core-collapse (CC) SNe (known to have short-lived progenitors). The closer locations of SNe Ibc vs. SNe II relative to the leading edges of the arms supports the belief that SNe Ibc have more massive progenitors. SNe Ia having less massive and older progenitors, show symmetric distribution with respect to the peaks of spiral arms.

1. Introduction

It is well known that star forming regions in spiral discs are generally concentrated in spiral arms (e.g. Seigar & James 2002). There are a variety of known structures of spiral galaxies, with different numbers and shapes of their arms (for recent review

- Анализируется положение 215 SN (SN Ibc, SN II, SN Ia) в 187 галактиках относительно максимумов яркости спиральных ветвей в GD и non-GD- галактиках.
- Каталог Hakobyan 2012 (3786 SN)



Определяется разность радиальных расстояний до SN и до ближайшей области спиральной ветви.

Figure 1. The scheme of star formation distribution in a model of two armed GD galaxy with the directions and relative sizes of drifts from birth places up to the explosion for SNe Ibc (blue arrow) and II (green arrow). For better visualization, the directions of drifts are shown with a significant radial component.

Выводы

- In non-GD galaxies the shortest mean distance to the peak of spiral arm is for SNe Ibc. SN Ia are less concentrated. In addition, the distribution of any SN type inside the spiral arms in NGD galaxies does not show any significant radial trend.
- Для GD- галактик сдвиг меняется с R_{SN}/R_{25}. Во внешних и внутренних областях галактик GD распределение SN зеркально меняется (коротация?). Условная граница $R = 0.45R_{25}$.
- Расстояние от лидирующей стороны спирали минимально для SN Ibc, затем- SN II (вероятность случайного – 0.01)

Too small to succeed: the difficulty of sustaining star formation in low-mass haloes

Claire R. Cashmore,[1]* Mark I. Wilkinson,[1] Chris Power[2] and Martin A. Bourne[1,3]
[1] *Department of Physics & Astronomy, University of Leicester, University Road, Leicester LE1 7RH*
[2] *International Centre for Radio Astronomy Research, University of Western Australia, 35 Stirling Highway, Crawley, Western Australia 6009, A*
[3] *Institute of Astronomy and Kavli Institute for Cosmology, University of Cambridge, Madingley Road, Cambridge CB3 0HA, UK*

Accepted XXX. Received YYY; in original form ZZZ

ABSTRACT

We present high resolution simulations of an isolated dwarf spheroidal (dSph) galaxy between redshifts $z \sim 10$ and $z \sim 4$, the epoch when several Milky Way dSph satellites experienced extended star formation, in order to understand in detail the physical processes which affect a low-mass halo?s ability to retain gas. It is well-established that supernova feedback is very effective at expelling gas from a $3 \times 10^7 \mathrm{M}_\odot$ halo, the mass of a typical redshift 10 progenitor of a redshift 0 halo with mass $\sim 10^9 \mathrm{M}_\odot$. We investigate the conditions under which such a halo is able to retain sufficient high-density gas to support extended star formation. In particular, we explore the effects of: an increased relative concentration of the gas compared to the dark matter; a higher concentration dark matter halo; significantly lower supernova rates; enhanced metal cooling due to enrichment from earlier supernovae. We show that disk-like gas distributions retain more gas than spherical ones, primarily due to the shorter gas cooling times in the disk. However, a significant reduction in the number of supernovae compared to that expected for a standard initial mass function is still needed to allow the retention of high density gas. We conclude that the progenitors of the observed dSphs would only have retained the gas required to sustain star formation if their mass, concentration and gas morphology were already unusual for those of a dSph-mass halo progenitor by a redshift of 10.

Key words: Galaxies: dwarf – galaxies: ISM – galaxies: formation – galaxies: evolution – stars: supernova – ISM: supernova

1 INTRODUCTION

and observations (Navarro et al. 1996a; Pontzen & Gover-

- Теоретически должен существовать нижний предел DM гало, в котором могут рождаться звезды.
- Однако есть карлики с $M_* < 10^6$Mc. Остается проблема объяснения слишком большого кол-ва минигало и проблема объяснения дотстаточно продолжительного периода SF (неск.. млрд лет) в карликах, несмотря на feedback.
- Simulations образования карликов типа Umi и Draco (N-body + hydrodynamics+radiative cooling. Particles: 10 Mc for gas and 100 Mv for DM.
- Начало:

z = 10, initial M_{halo} (z=10) = 3 10^7 , M_{halo} (z=0)~10^9 Mc.

Simulations: два типа моделей: толстый диск и сфера

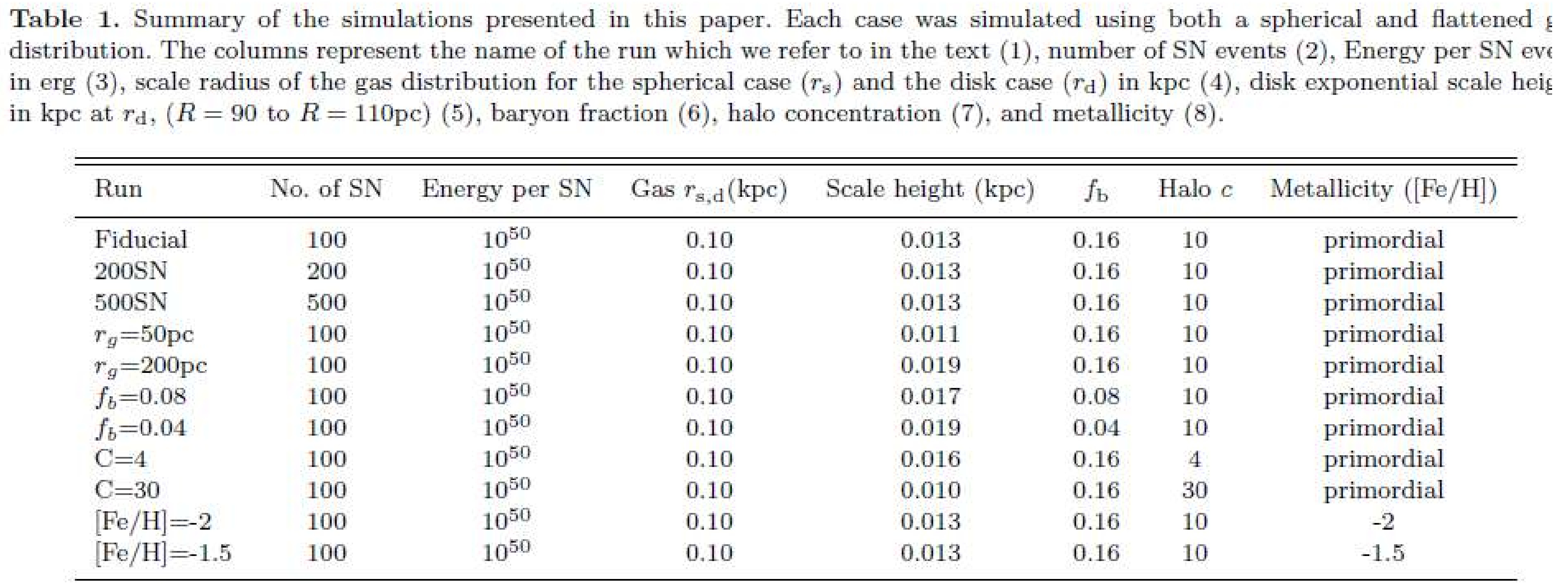


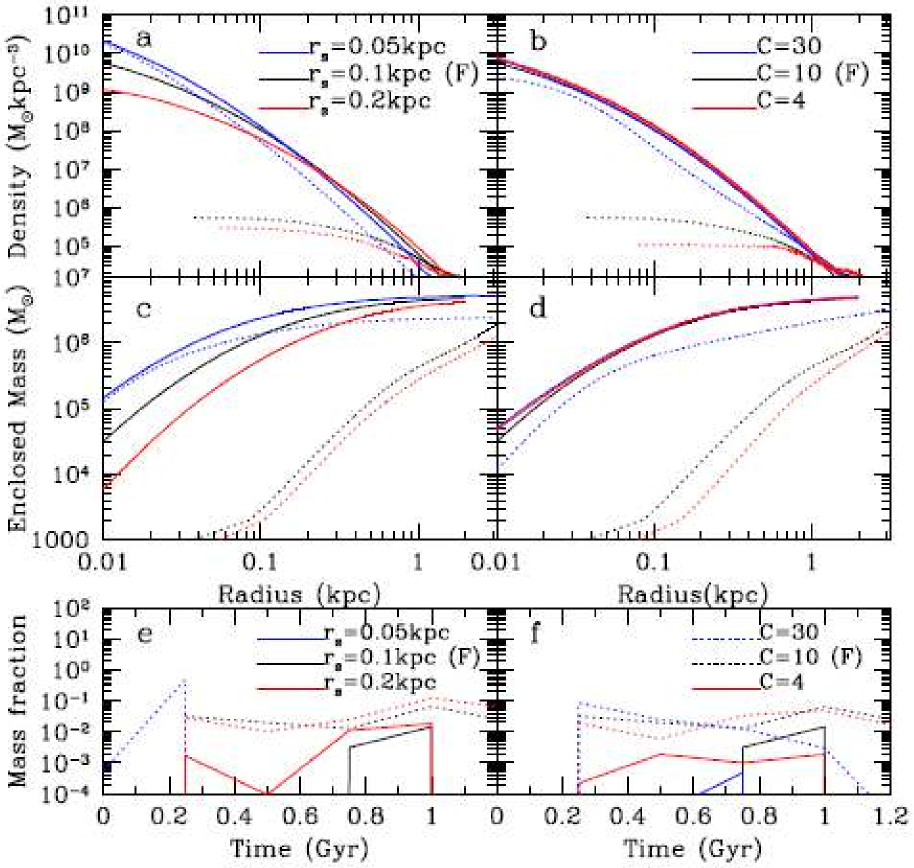
Table 1. Summary of the simulations presented in this paper. Each case was simulated using both a spherical and flattened g
distribution. The columns represent the name of the run which we refer to in the text (1), number of SN events (2), Energy per SN eve
in erg (3), scale radius of the gas distribution for the spherical case (r_s) and the disk case (r_d) in kpc (4), disk exponential scale heig
in kpc at r_d, ($R = 90$ to $R = 110$pc) (5), baryon fraction (6), halo concentration (7), and metallicity (8).

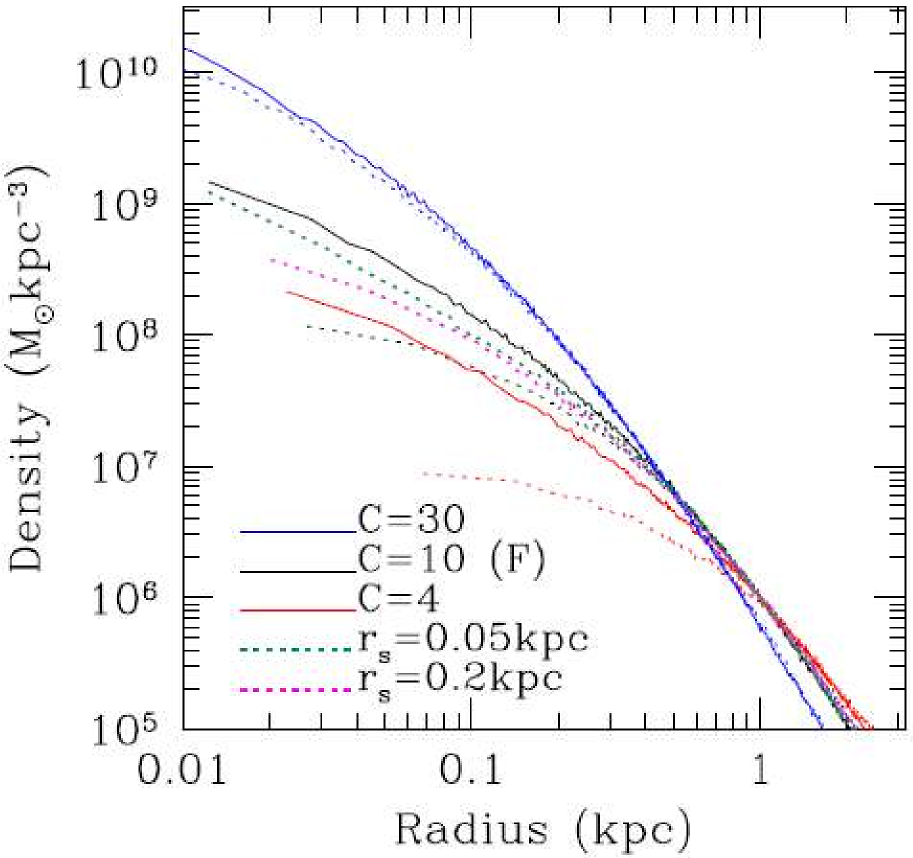
Run	No. of SN	Energy per SN	Gas $r_{\mathrm{s,d}}$(kpc)	Scale height (kpc)	f_b	Halo c	Metallicity ([Fe/H])
Fiducial	100	10^{50}	0.10	0.013	0.16	10	primordial
200SN	200	10^{50}	0.10	0.013	0.16	10	primordial
500SN	500	10^{50}	0.10	0.013	0.16	10	primordial
r_g=50pc	100	10^{50}	0.10	0.011	0.16	10	primordial
r_g=200pc	100	10^{50}	0.10	0.019	0.16	10	primordial
f_b=0.08	100	10^{50}	0.10	0.017	0.08	10	primordial
f_b=0.04	100	10^{50}	0.10	0.019	0.04	10	primordial
C=4	100	10^{50}	0.10	0.016	0.16	4	primordial
C=30	100	10^{50}	0.10	0.010	0.16	30	primordial
[Fe/H]=-2	100	10^{50}	0.10	0.013	0.16	10	-2
[Fe/H]=-1.5	100	10^{50}	0.10	0.013	0.16	10	-1.5

Профиль Hernquist $\rho(r) = \frac{M_{200}}{2\pi} \frac{a_\mathrm{h}}{r(r + a_\mathrm{h})^3}$

Эволюция сферической галактики

- Сплошные линии – начальные профили,
- Пунктироые – через 1.25 Gyr





- Менее 5% газа навсегда покидает галактикку, но плоотность газа падает на 2 порядка, и газ легко теряется.

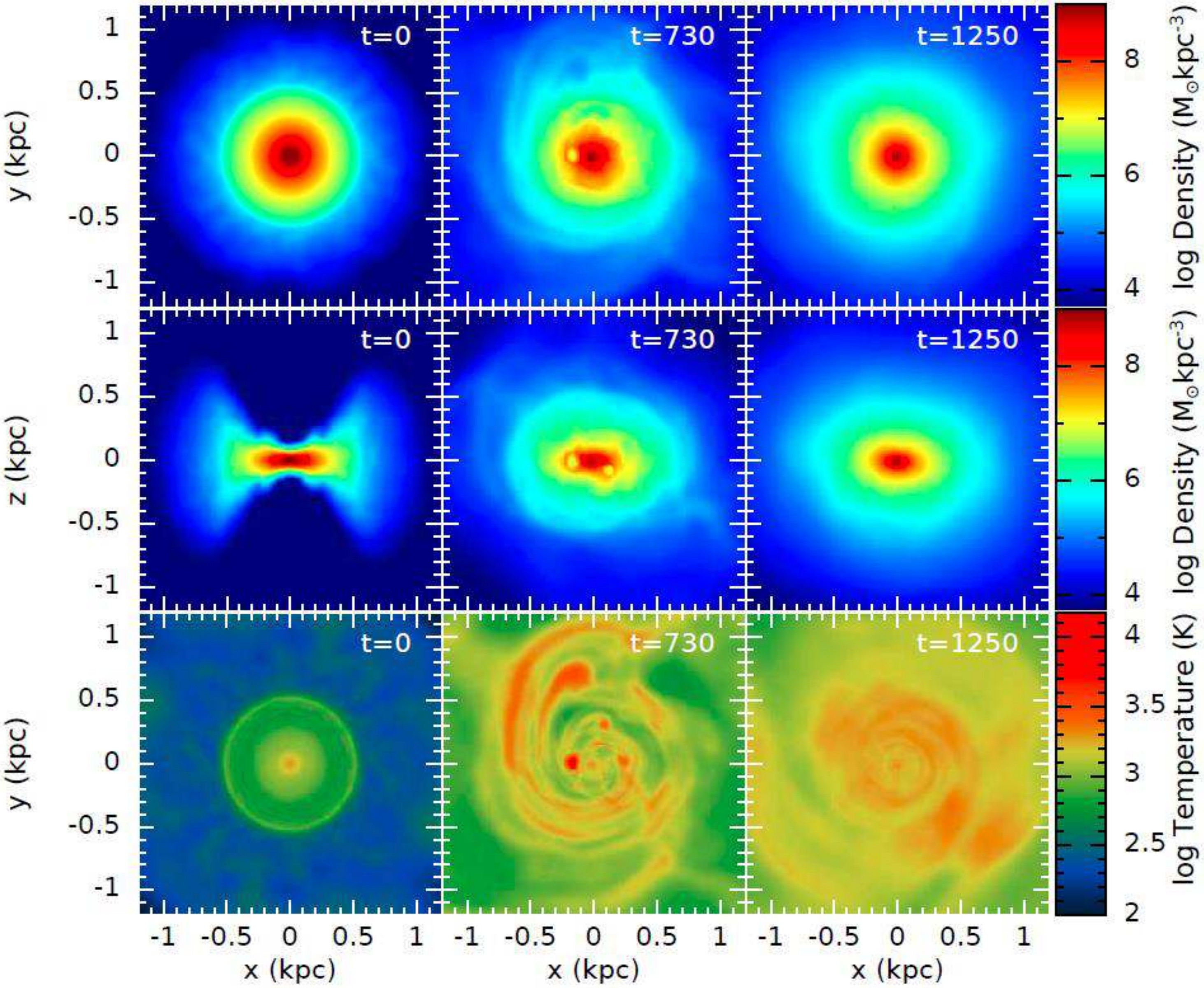


Figure 4. Maps showing the evolution of gas density (**top, middle**) and temperature (**bottom**) for the fiducial disk simulation. The leftmost column shows the initial conditions, the middle column shows the situation at 730 Myr and the rightmost column shows the final state at 1.25 Gyr. The quantities plotted are cross-sections showing density in the $x-y$ plane (top panel), density in the $x-z$ plane and temperature in the $x-y$ plane.

Выводы

- A flattened gas distribution (disk) is overall more efficient at retaining gas than a spherical distribution due to the fact that the gas densities are generally higher initially.
- However, even with a high gas or halo concentration, we found that high density gas only remains at the end of the simulation period if the number of SN events is lower than that expected from a Salpeter IMF (assuming a total stellar mass of $3 \ 10^5 M$).
- Successful dSphs may therefore result from progenitors which were outliers in the distribution of halo/gas properties at $z = 10$, as well as experiencing gas accretion at an appropriate rate and with an appropriate morphology so that SN-driven outflows were unable to prevent further gas accretion.