Why is the dark-matter approach ill-fated ?

First PoR Meeting

Observatoire astronomique de Strasbourg
21st of September 2015

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Some of the perhaps major arguments why dark matter particles cannot exist :

- Rotation curves and fine-tuning between "dark matter" and standard matter

- Lack of bulge-dominated disk galaxies

- No increase in number ratio of elliptical to disk galaxies with cosmic time

- Lack of evidence for dynamical friction :
  explicit examples:
    - M81 group,
    - Sagittarius satellite,
    - LMC/SMC companion galaxies

- Disk of Satellites (DoSs/VPOSs/GPoA) around MW, Andromeda, M81 . . .

- Symmetric structure of Local Goup

- Local underdensity

Rotation

curves

and fine tuning

3

**Rotation curves
OR
mass-discrepancy -- acceleration
correlation**

Wu & Kroupa 2015
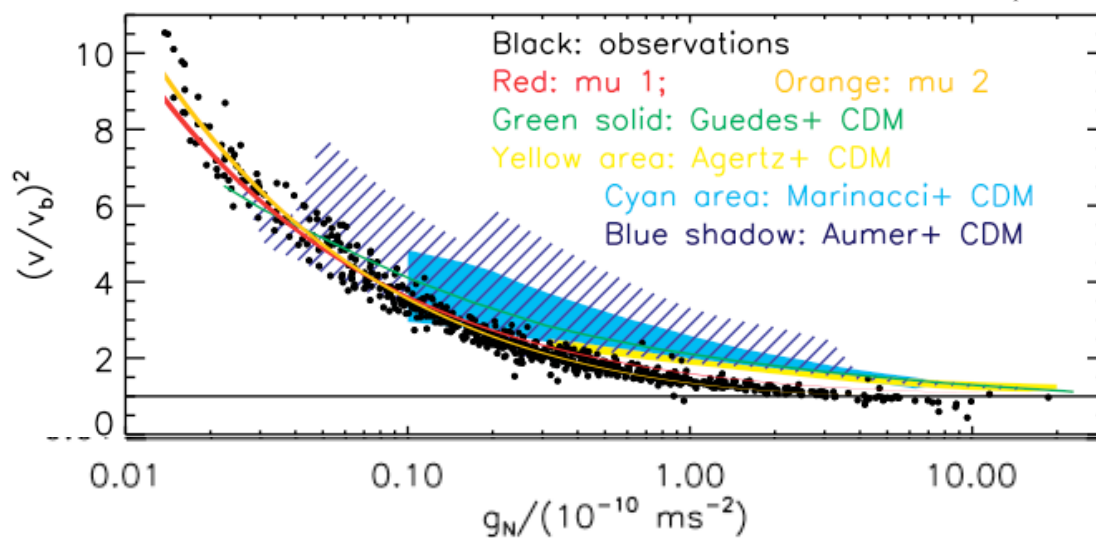
Renzo's rule

Renzo's Rule: "For any feature in the luminosity profile there is a corresponding feature in the rotation curve and vice versa." (Sancisi 2004, IAU 220, 233)
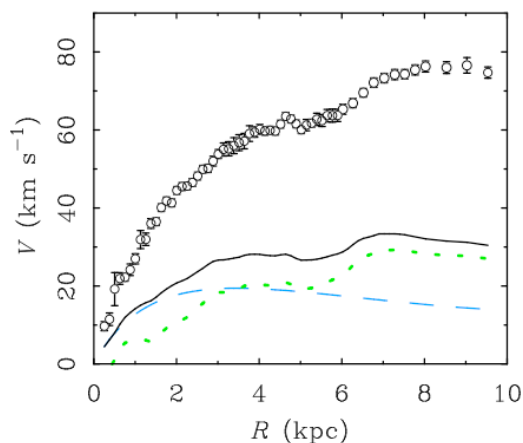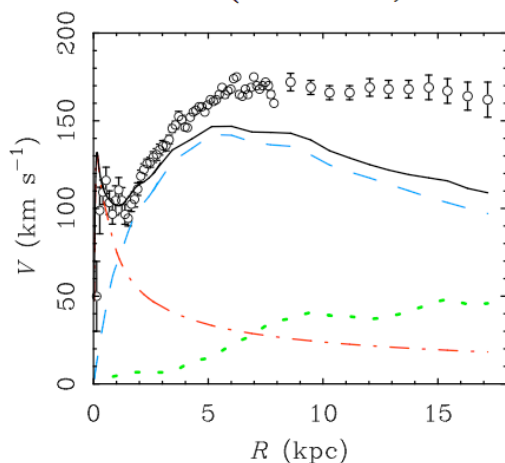
Tuesday, February 28, 2012   Stacy McGaugh, Univ. Maryland   KITP DwarfGal

"What is distinctly unnatural is for the baryons to have a perceptible impact where dark matter must clearly dominate." (c.f. LSBs vs HSBs)

Famaey & McGaugh 2012

5

Lack of bulge-dominated disk galaxies

6

"Puech et al. [154] emphasize this tension between observed galaxies and the SMoC and argue that galactic disks may be rebuilt after significant mergers implying that half of all disk galaxies ought to have disks younger than 9 Gyr.

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This nevertheless does not solve the problem that more than half of all disk galaxies with circular velocity >150 km/s have no classical bulge [149], while Fernández Lorenzo et al. [150] deduce 94% of their disk galaxy sample to not have a classical bulge.

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The evidence of early formation times at high redshift and short (<2 Gyr) formation timescales of E galaxies also contradicts the merger-driven build-up over time of the galaxy population [Matteucci 2003: 57]. Naab and Ostriker [155] confirm that E galaxies cannot have been forming from disk galaxy mergers."

9

No increase in number ratio of E to other galaxies

10

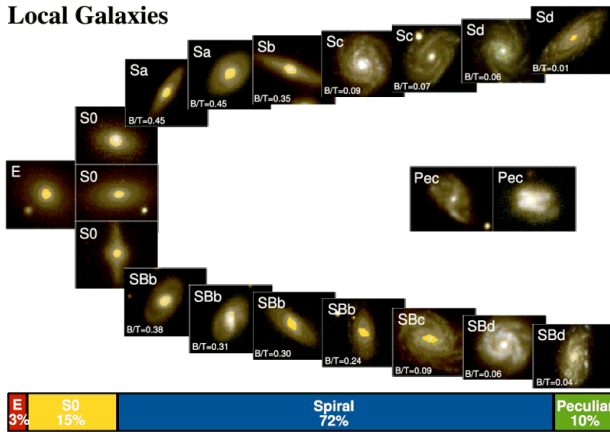**Ratio of massive to less-massive galaxies does not evolve, in conflict with LCDM expectations**
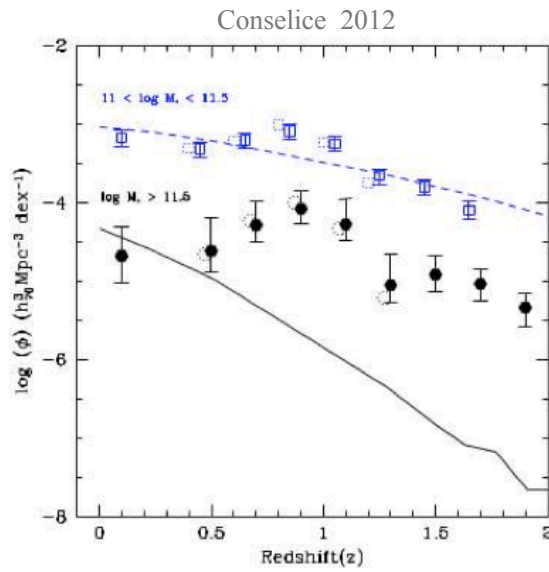
Conselice 2012

Ratio of E to other galaxies unchanging ?

Delgado-Serrano et al. (2010)

Galaxy mass in baryons
$> 1.5 \times 10^{10}$ Msun

6 Gyr ago

Local Galaxies

Sa Sa Sb Sc Sc Sd Sd
S0 B/T=0.45 B/T=0.35 B/T=0.09 B/T=0.07 B/T=0.06 B/T=0.01
E S0 Pec Pec
S0
SBb SBb SBb SBb SBc SBd SBd
B/T=0.38 B/T=0.31 B/T=0.30 B/T=0.24 B/T=0.09 B/T=0.06 B/T=0.04

| E 3% | S0 15% | Spiral 72% | Peculiar 10% |

Distant Galaxies

Sd
Sc B/T=0.06
Sa B/T=0.14
S0 B/T=0.47 Pec Pec
E S0 Pec Pec Pec
S0 Pec Pec Pec
SBb Pec Pec
B/T=0.38 SBc
SBd
B/T=0.11
B/T=0.05

| E 4% | S0 13% | Spiral 31% | Peculiar 52% |

13

Ratio of E to other galaxies unchanging ?

Delgado-Serrano et al. (2010)
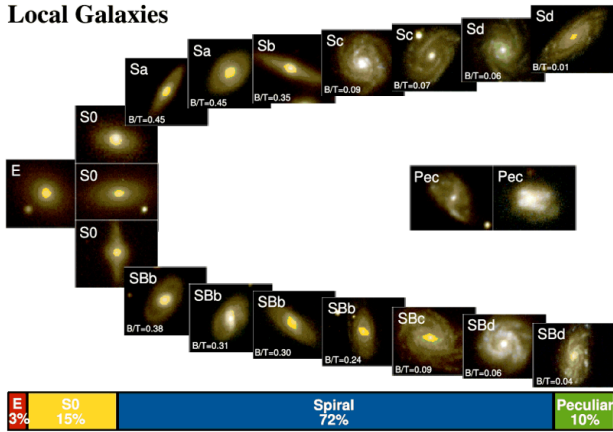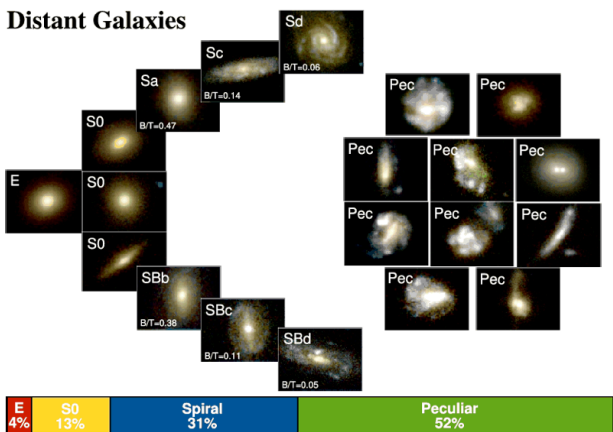
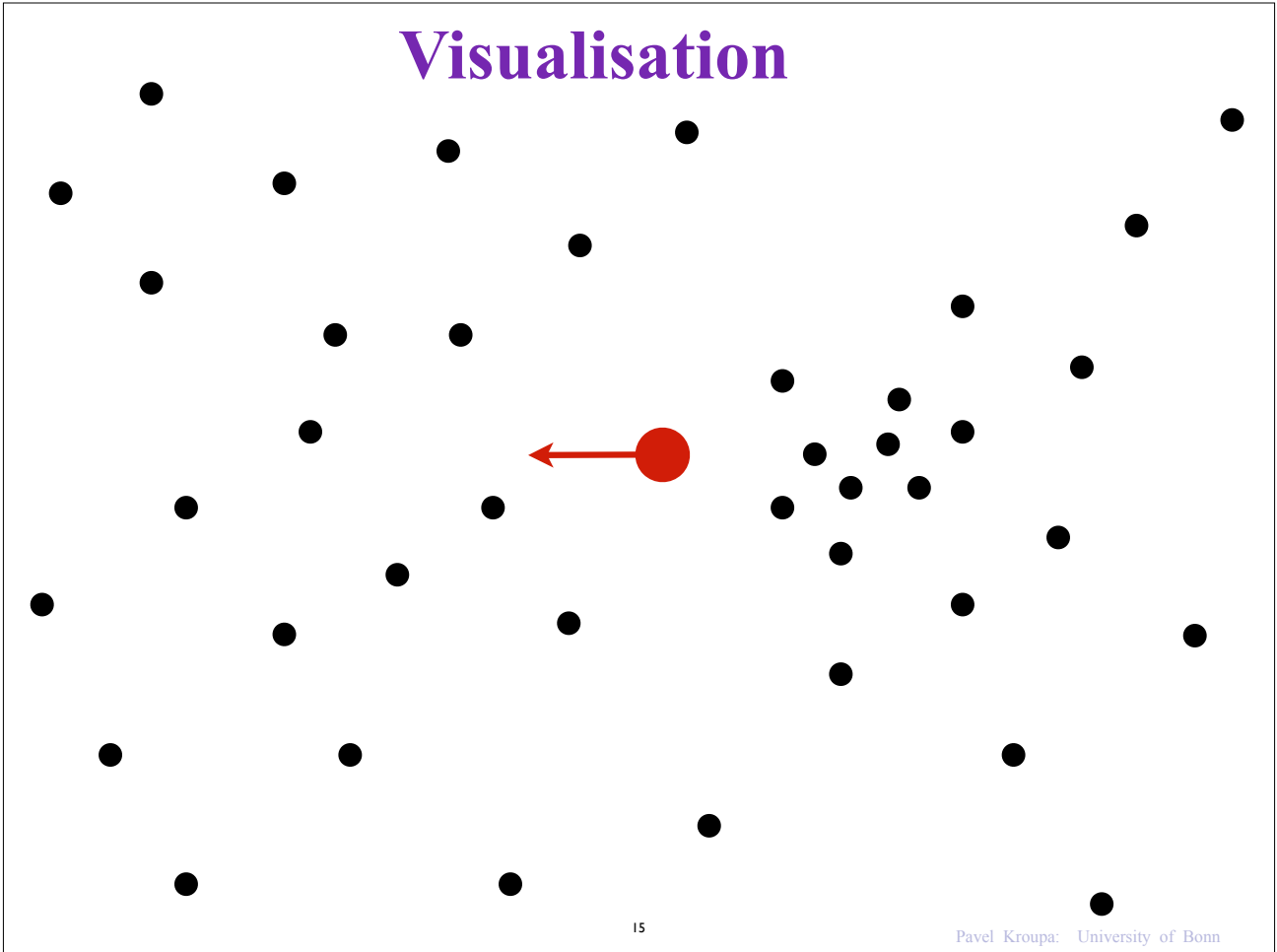**Galaxy mass in baryons**
$> 1.5 \times 10^{10}$ Msun

6 Gyr ago

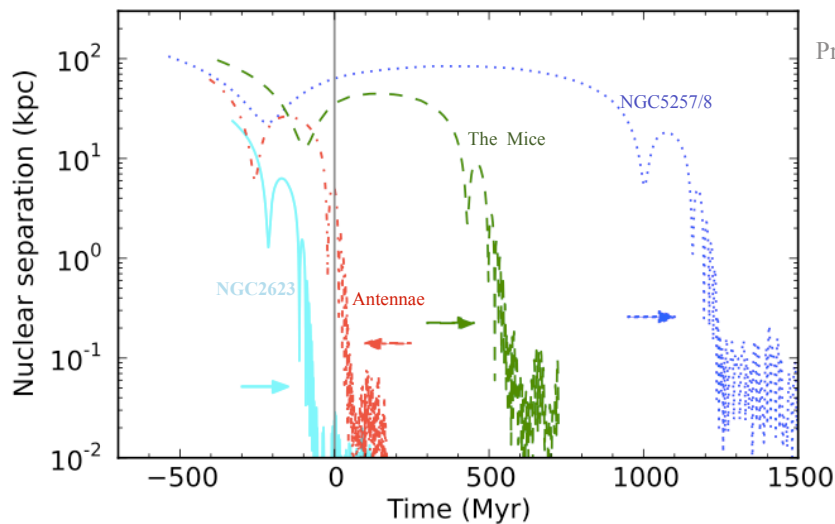Pavel Kroupa: University of Bonn

Dynamical Friction

14

Pavel Kroupa: University of Bonn

Visualisation

15

Dynamical friction?? : galaxy mergers - are they really common?

Galaxy encounters with mass ratio = 1 : mergers within 0.5-3 Gyr

Privon, Barnes et al. 2013

Barnes (1998) in "Dynamics of Galaxy Interactions" :

"Interacting galaxies are well-understood in terms of the effects of gravity on stars and dark matter."

Figure 1. True nuclear separation as a function of time for NGC 5257/8 (dotted blue line), The Mice (dashed green), Antennae (dash-dot red), and NGC 2623 (solid cyan). Time of zero is the current viewing time (solid gray vertical line). The time since first passages for these systems is $175 - 260$ Myr (cf. Table 2). Colored arrows mark the smoothing length in kpc for the corresponding system; this is effectively the spatial resolution of our simulations and the behavior of the curves on length scales smaller than the smoothing length is not reliable.

Pavel Kroupa: University of Bonn

Each MW satellite has a pre-infall DM halo :
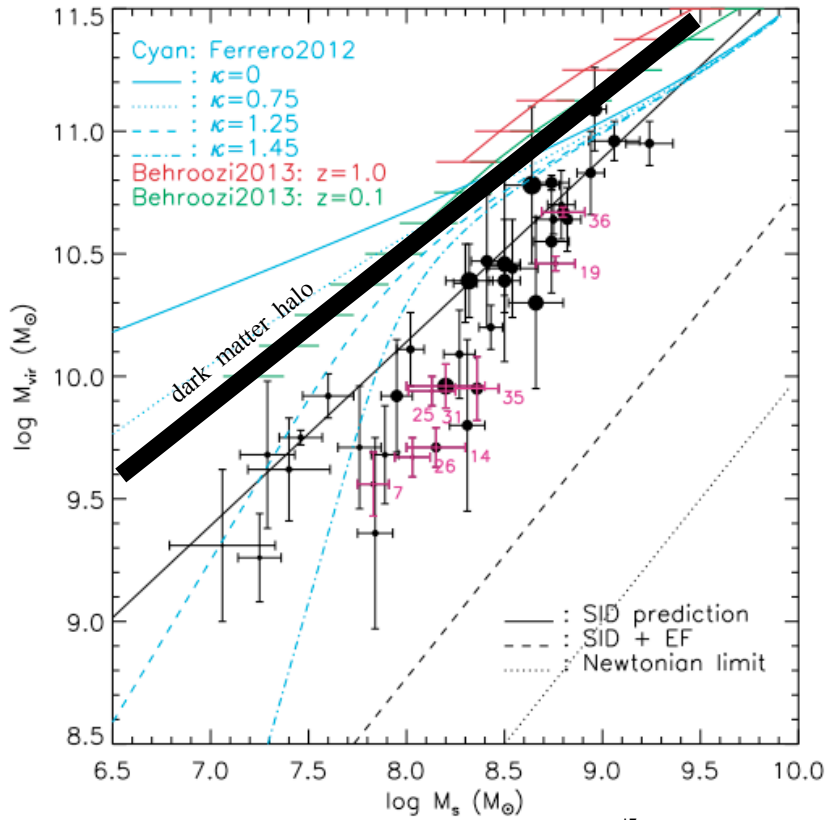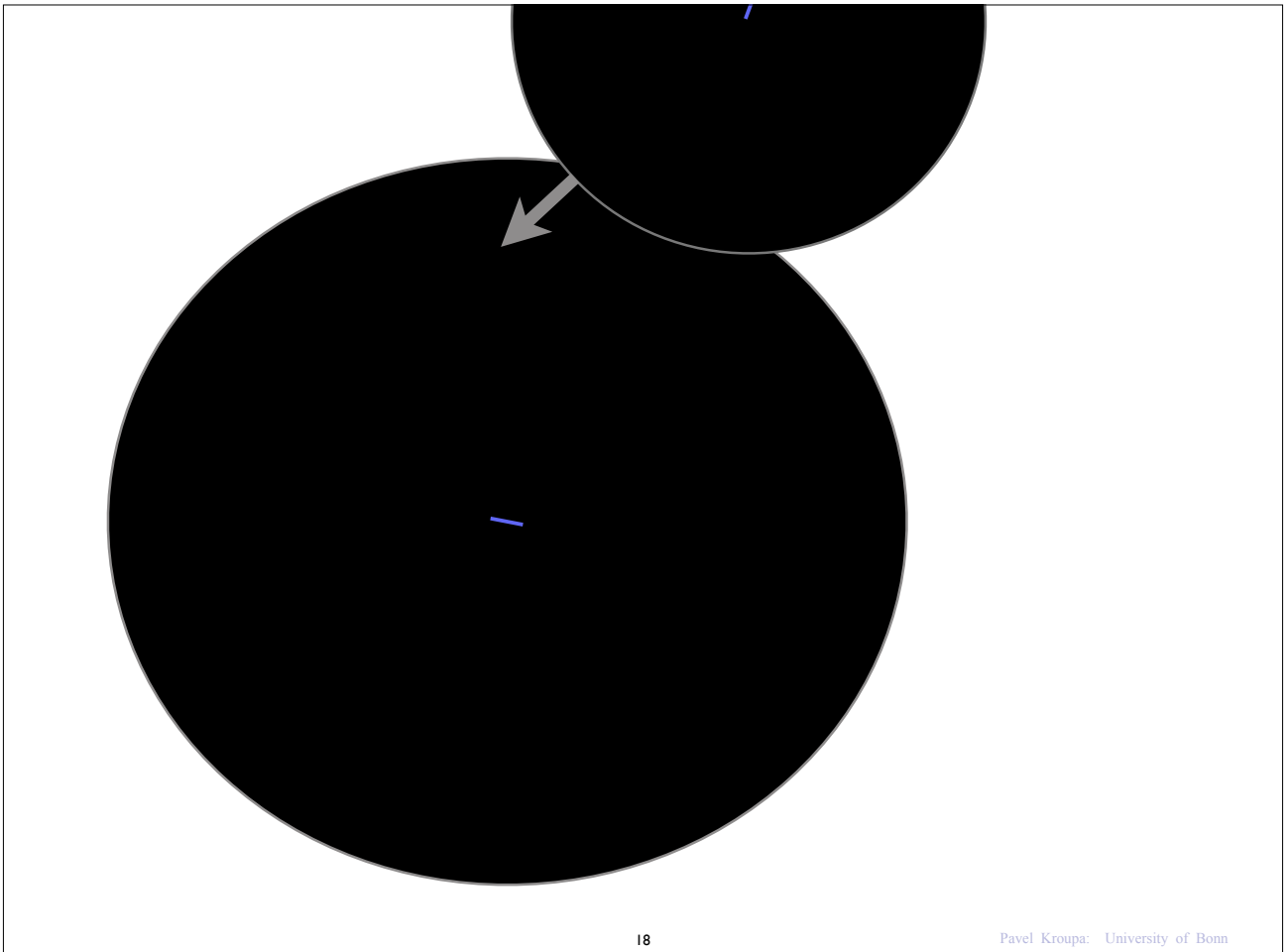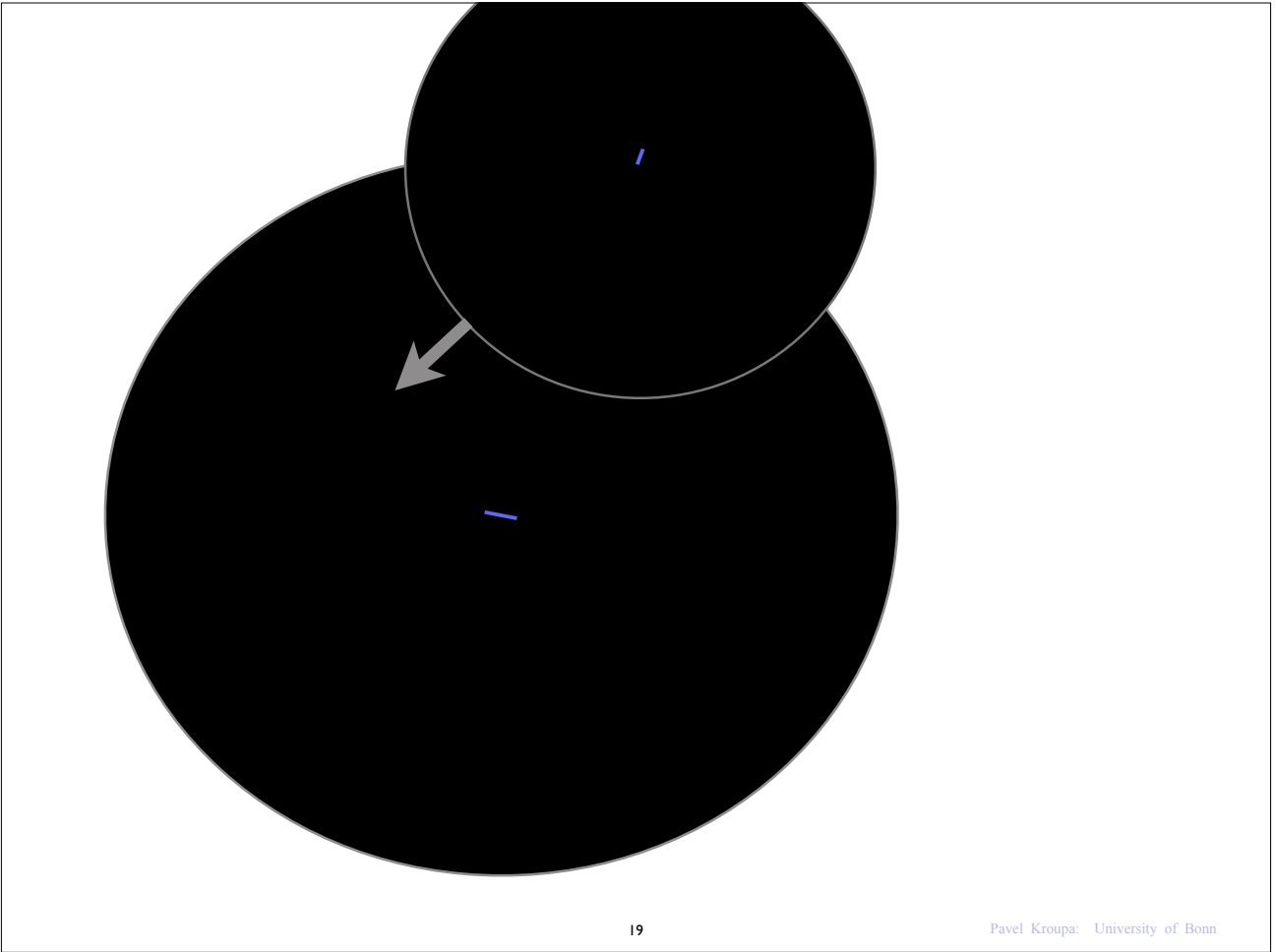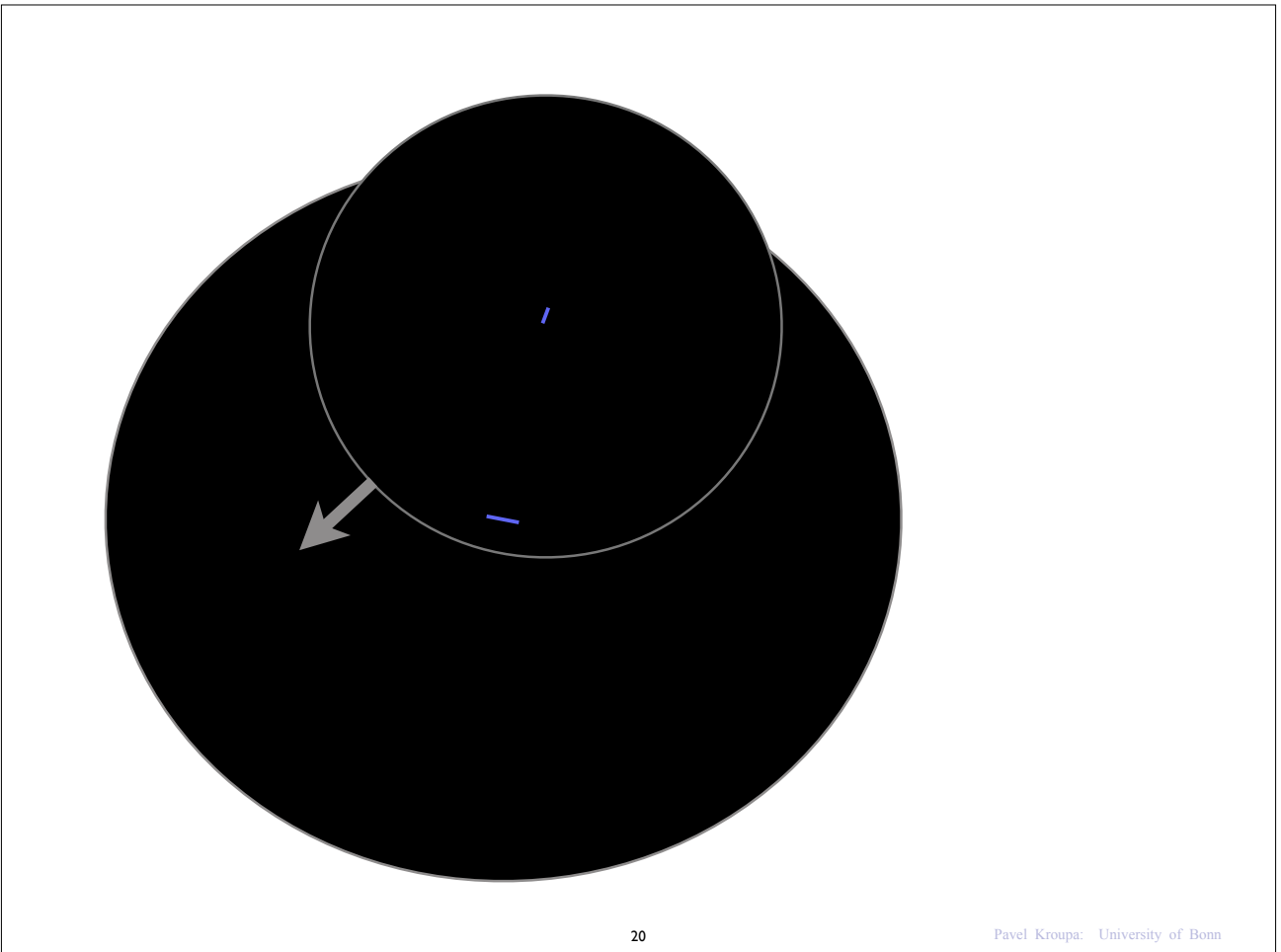

Wu & Kroupa 2015, MNRAS

E.g. a 10^8 Msun pre-infall

satellite

ought to have had a

DM halo mass $> 10^{10}$ Msun
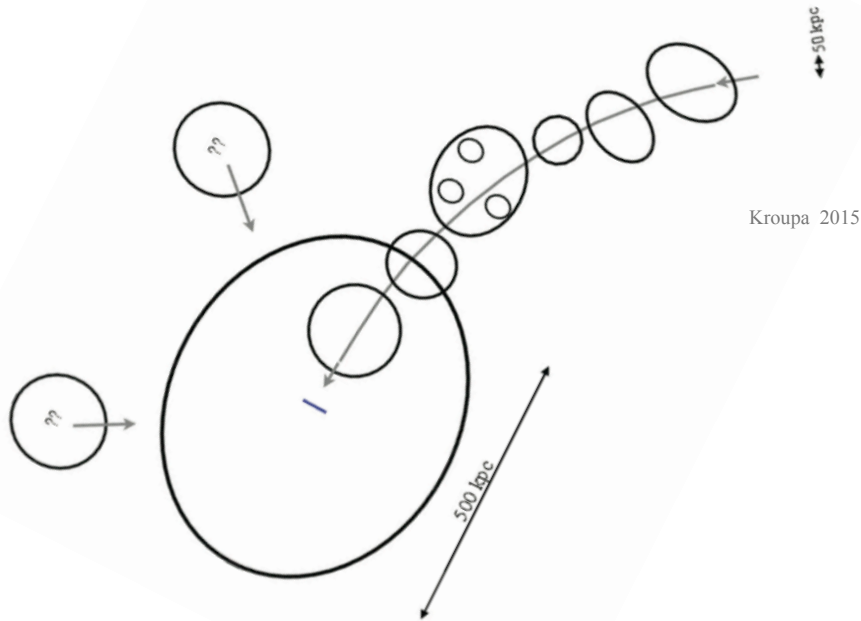
such that its orbital decay time

would be short.

Pavel Kroupa: University of Bonn

Montag, 21. September 15

Pavel Kroupa: University of Bonn

Montag, 21. September 15

Slide 21

Infall from a filament ? **NO !!**

Kroupa 2015

Slide 22

Using dwarf satellite proper motions to determine their origin

G. W. Angus,[1,2,3]* Antonaldo Diaferio[2,3,4] and Pavel Kroupa[5]

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[2] Dipartimento di Fisica Generale 'Amedeo Avogadro', Università degli studi di Torino, Via P. Giuria 1, I-10125 Torino, Italy
[3] Istituto Nazionale di Fisica Nucleare (INFN), Sezione di Torino, Torino, Italy
[4] Harvard–Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA
[5] Argelander Institute for Astronomy, University of Bonn, Auf dem Hügel 71, D-53121 Bonn, Germany

Table 2. Galactocentric distances and velocities of the dSphs. For Fornax, Sculptor and Ursa Minor, our V_{x_0} corresponds to Piatek et al. (2003, 2005, 2006, 2007a) V_r and our V_{y_0} to their V_t. For Carina, the proper motion comes directly from Pasetto et al. (2011). Distances come from Mateo (1998).

dSph	r_0 (kpc)	V_{x_0} (km s^{-1})	V_{y_0} (km s^{-1})
Fornax	138 ± 8	-31.8 ± 1.7	196 ± 29
Sculptor	87 ± 4	79 ± 6	198 ± 50
Ursa Minor	76 ± 4	-75 ± 44	144 ± 50
Carina	101 ± 5	113 ± 52	46 ± 54

ABSTRACT

The highly organized distribution of satellite galaxies surrounding the Milky Way is a serious challenge to the concordance cosmological model. Perhaps the only remaining solution, in this framework, is that the dwarf satellite galaxies fall into the Milky Way's potential along one or two filaments, which may or may not plausibly reproduce the observed distribution. Here we test this scenario by making use of the proper motions of the Fornax, Sculptor, Ursa Minor and Carina dwarf spheroidals, and trace their orbits back through several variations of the Milky Way's potential and account for dynamical friction. The key parameters are the proper motions and total masses of the dwarf galaxies. Using a simple model, we find no tenable set of parameters that can allow Fornax to be consistent with filamentary infall, mainly because the 1σ error on its proper motion is relatively small. The other three must walk a tightrope between requiring a small pericentre (less than 20 kpc) to lose enough orbital energy to dynamical friction and avoiding being tidally disrupted. We then employed a more realistic model with host halo mass accretion and found that the four dwarf galaxies must have fallen in at least 5 Gyr ago. This time-interval is longer than organized distribution is expected to last before being erased by the randomization of the satellite orbits.

Using dwarf satellite proper motions to determine their origin

G. W. Angus,[1,2,3]★ Antonaldo Diaferio[2,3,4] and Pavel Kroupa[5]

[1]*Astrophysics, Cosmology & Gravity Centre, University of Cape Town, Private Bag X3, Rondebosch 7700, South Africa*
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Therefore . . .

The present-day motions and distances of MW satellites preclude them to have fallen-in from a filament if they have dark-matter halos.

→   inconsistency with the dark-matter model

Sagittarius: on a high-energy orbit but still not merged **?**
LMC/SMC: In DoS so cannot be on first-passage **?**

Other Consequences

The M81 group of galaxies

~ an analogue to the Local Group

Constraints on the existence of dark matter halos by the galaxy group M81

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[1] scdsoft AG, Albert-Nestler-Str. 10, D-76131 Karlsruhe, Germany
[2] Helmholtz-Institut für Strahlen und Kernphysik (HISKP), Nussallee 14-16, D-53115 Bonn, Germany

ABSTRACT
According to the standard model of cosmology, galaxies are embedded in dark matter halos, thus extending the mass and the size of the visible baryonic matter by one or two orders of magnitude. By means of this hypothesis, which claims an extension to the standard model of particle physics, observed deviations from Newtonian dynamics in galactic dynamical processes find, at a first glance, their appropriate explanation. However, incorporating the influence of dynamical friction established by Chandrasekhar, we obtain the result for the inner M81 group of galaxies that the existence of dark matter halos appears to be implausible. To be precise, the inner M81 group merges too rapidly making the initial pre-interaction phase-space configuration extremely unlikely. This result is derived by the employment of two separate and independent statistical methods, namely a Markov chain Monte Carlo method and the genetic algorithm. Without any exception, all numerical computations have been performed by means of SAP's *ABAP* development workbench, thus facilitating a program development time at least two or three times faster compared to the development environments of *FORTRAN* or *C++*. The conclusions reached here are discussed in view of independent evidence for dark-matter-induced dynamical friction being a relevant process in galaxy evolution.

Key words: galactic dynamics - dark matter - standard model of cosmology - computational methods
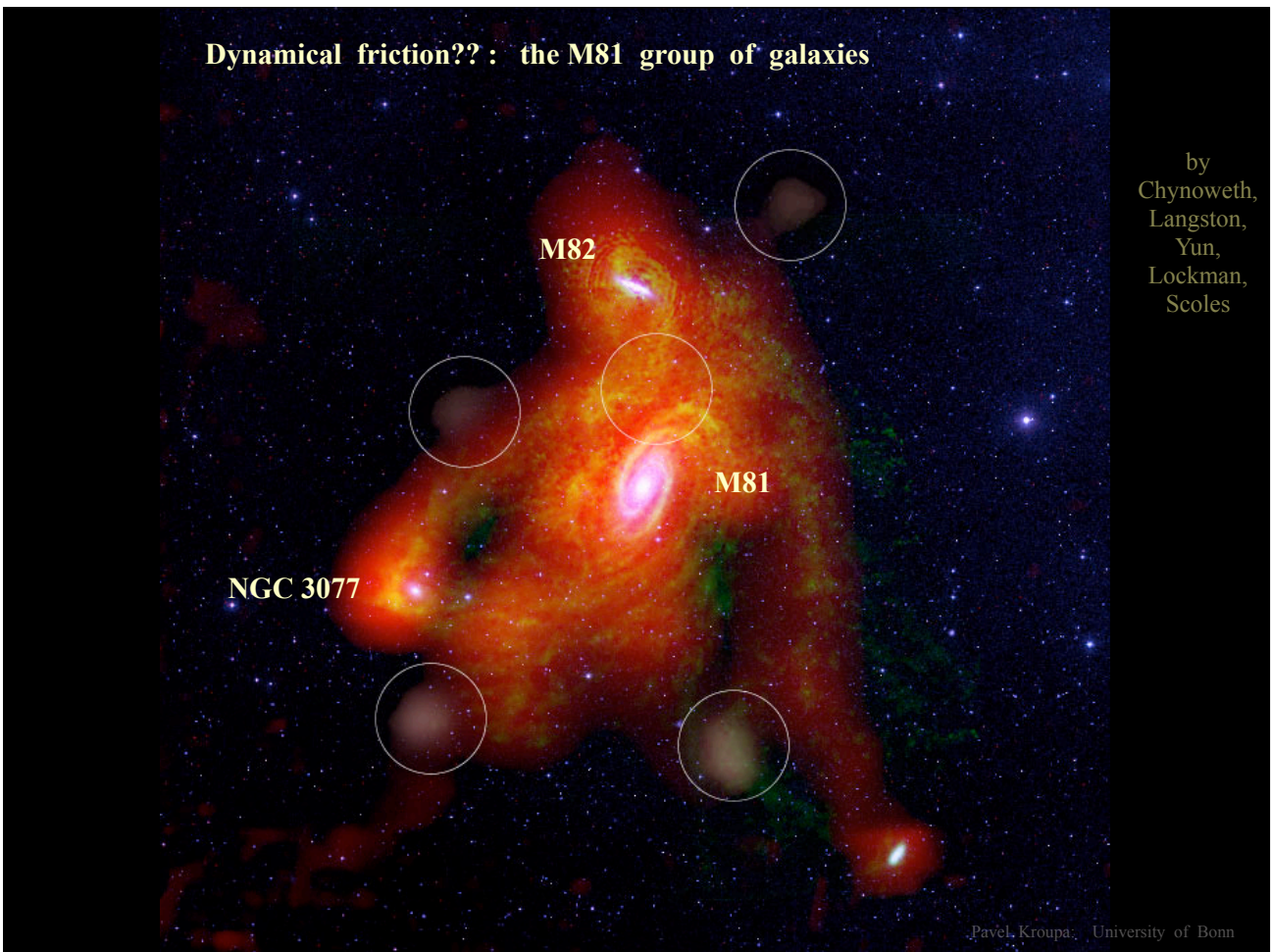
Dynamical friction?? : the M81 group of galaxies

M82

M81

NGC 3077

by Chynoweth, Langston, Yun, Lockman, Scoles
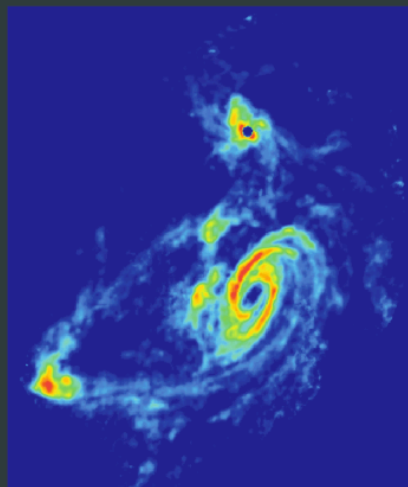
Pavel Kroupa: University of Bonn

Dynamical friction?? : the M81 group of galaxies

TIDAL INTERACTIONS IN M81 GROUP

Stellar Light Distribution

21 cm HI Distribution

Last publications (conference proceedings only) :

Yun 1999
=> no solutions with dark matter : system merges

Thomson, Laine & Turnbull 1999
=> no solutions with dark matter : system merges

28

Pavel Kroupa: University of Bonn

The M81 group must have assembled through the infall of the individual galaxies according to the merger tree which is a necessary part of the hierarchical structure formation in the SMoC. The currently observed configuration of the M81 group constrains the pre-infall initial conditions since for example tightly bound initial conditions are most likely ruled out given that the M81 group has not merged yet to an early-type galaxy."

3.4   Approach

Details regarding the numerical solution of our three-body problem at stake are presented in Appendix C.

At first, calculating three-body orbits backwards up to -7 Gyr, statistical populations for the open parameters are generated by means of the methods of Sections 4 (MCMC) and 5 (GA). Additionally to the known initial conditions at present, we added the rather general condition (later referred to as *COND*) that

> *both companions M82 and NGC 3077 encountered M81 within the recent 500 Myr at a pericentre distance below 30 kpc.*

Each three-body orbit of those populations is fully determined by all the known (Table 1) and open parameters (Table 2, provided by either MCMC or GA) because all together specify a complete set of initial conditions at present. Calculating the corresponding three-body orbits forward in time up to $+7$ Gyr thereafter, the behaviour of the inner group is investigated with respect to the question of possibly ocurring mergers in the future. As we will see, statistically significant conclusions can be drawn from those results.

Results

The results arrived at here strongly exclude the process of dynamical friction having played a role in the M81 group of galaxies: if the extensive and massive DM halos were present, then for the M81 system of galaxies to exist in its current pre-merger configuration is extremely unlikely.
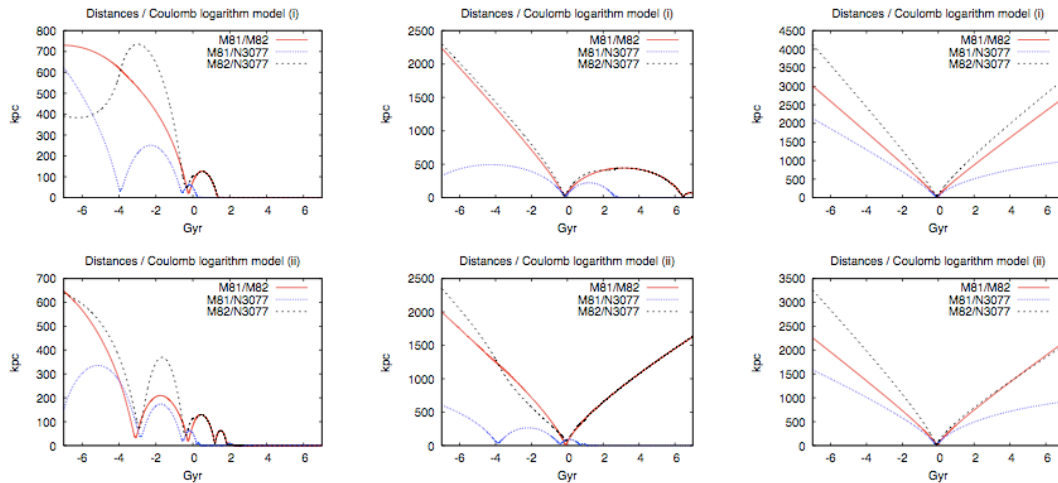

Figure 8. GA: Typical solutions for the three-body orbits presented as distances between the galaxies in the time interval from − 7 Gyr to 7 Gyr. For each Coulomb logarithm model ((*i*) at top, (*ii*) at bottom) we selected examples with merging galaxies, as well as an example for each model, where the companions both arrive from a far distance and no merger process occurs (see Table 5 and Appendix D for an assessment).

. . . basically, all members of the M81 group would have to have fallen in synchronously from large distances and have a peri-galactic encounter with M81 at nearly the same time without having merged yet.
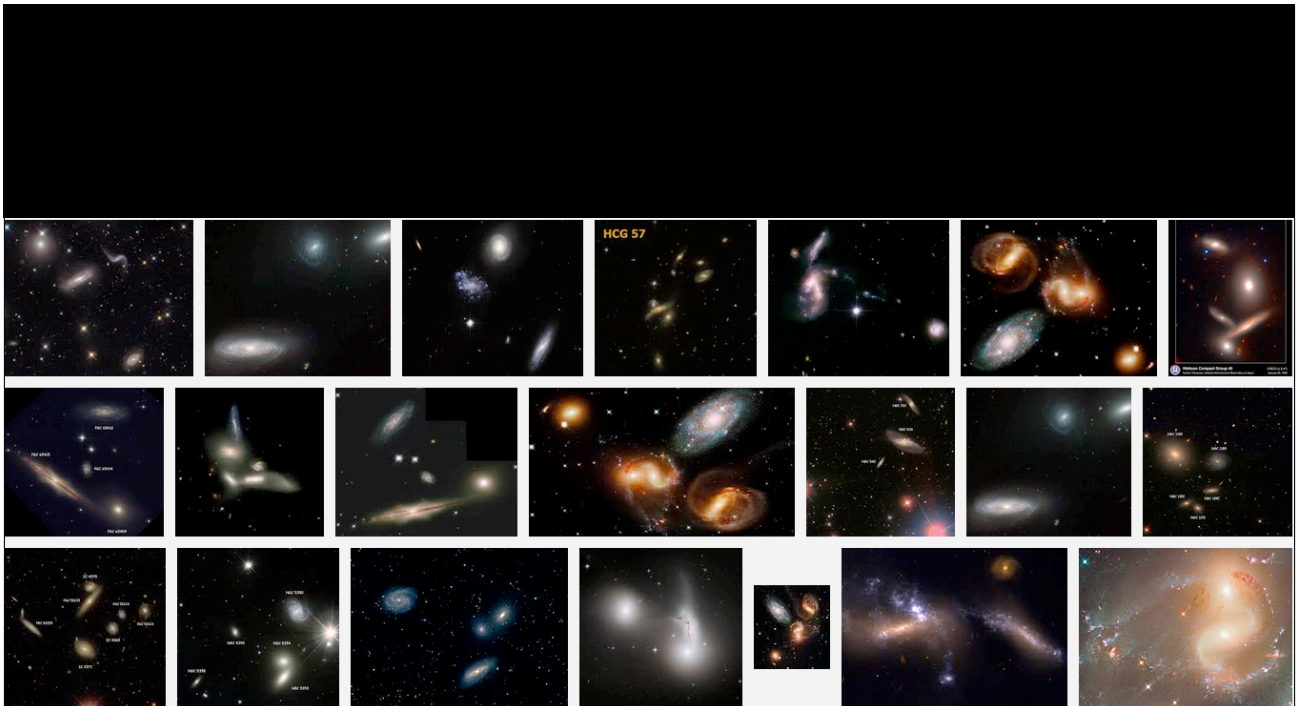
This is arbitrarily unlikely.

AND, there are many other similar groups.

The *Hickson compact groups* are are particularly troubling for LCDM, because they all must have assembled during the past 1-3 Gyr with all members magically coming together for about one synchronised perigalactic passage, while the remnants (field E galaxies with low alpha element abundances from previously such formed groups) do not appear to exist in sufficient numbers.

silkscape.com

Pavel Kroupa: University of Bonn

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silkscape.com

From various surveys (Delgado-Serrano et al. 2010; Conselice 2012) we know that the co-moving volume number ratio (E/S galaxies) does not evolve with redshift.

Abundances and ages of most field E galaxies and of fossil group E galaxies are very similar to Es in clusters (Pompei & Iovino 2012).

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citing from <u>COSMOS - The SAO Encyclopedia of Astronomy</u> on Hickson Compact groups:

"The velocities measured for galaxies in compact groups are quite low (~200 km/s), making these environments highly conducive to <u>interactions</u> and mergers between galaxies.

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only a fossil group.

37

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This would mean that compact groups are a shorted-lived phase
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38

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rare.

Instead, we find a significant number of compact groups in the
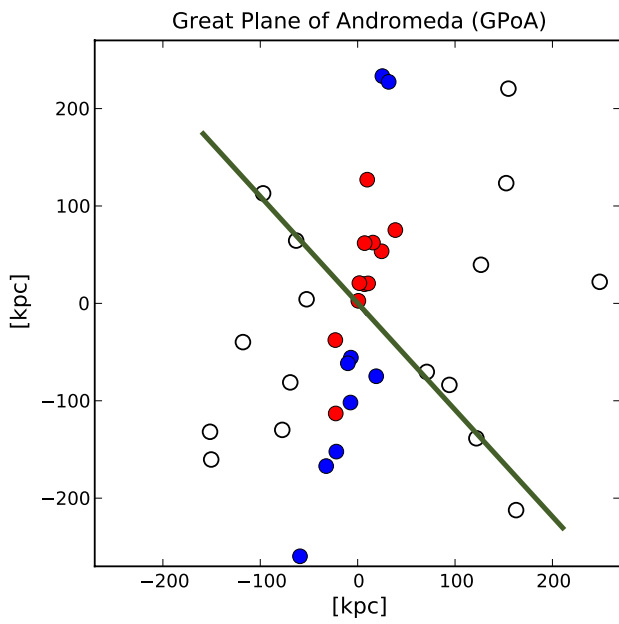nearby Universe, with well over 100 identified."

39

DoS / VPOS / GPoA

and
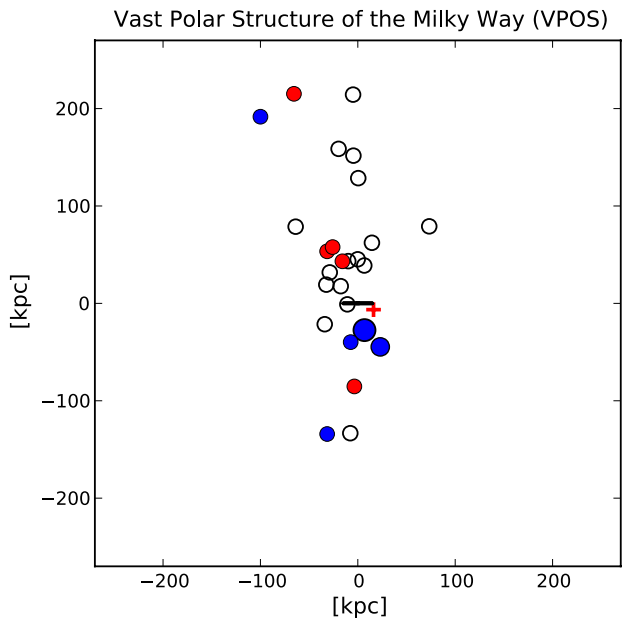
the frightening symmetry
of the Local Group

40

Andromeda

Milky Way

Great Plane of Andromeda (GPoA)

Ibata et al. 2013, 2014

Vast Polar Structure of the Milky Way (VPOS)

Kroupa et al. 2005;
Pawlowski & Kroupa 2013

41

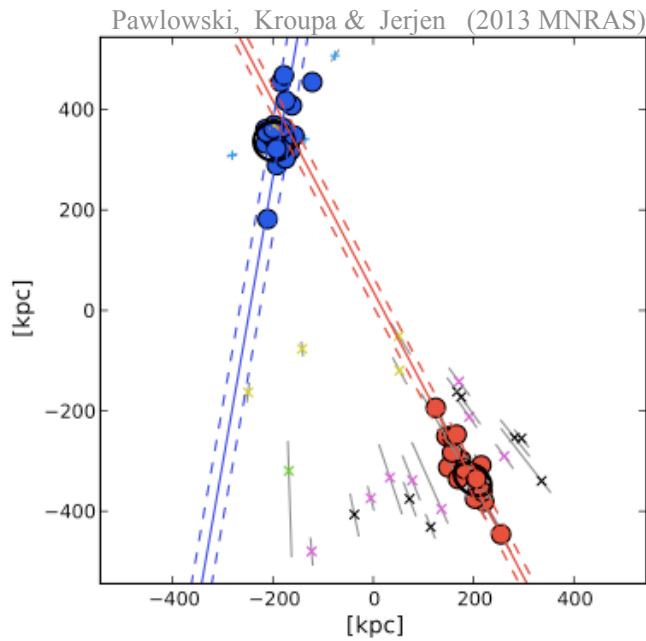Pawlowski, Kroupa & Jerjen   (2013 MNRAS)

Figure 16. Edge-on view of the satellite galaxy planes around the MW and M31, similar to Fig. 9 for the LG planes. As before, galaxies which are
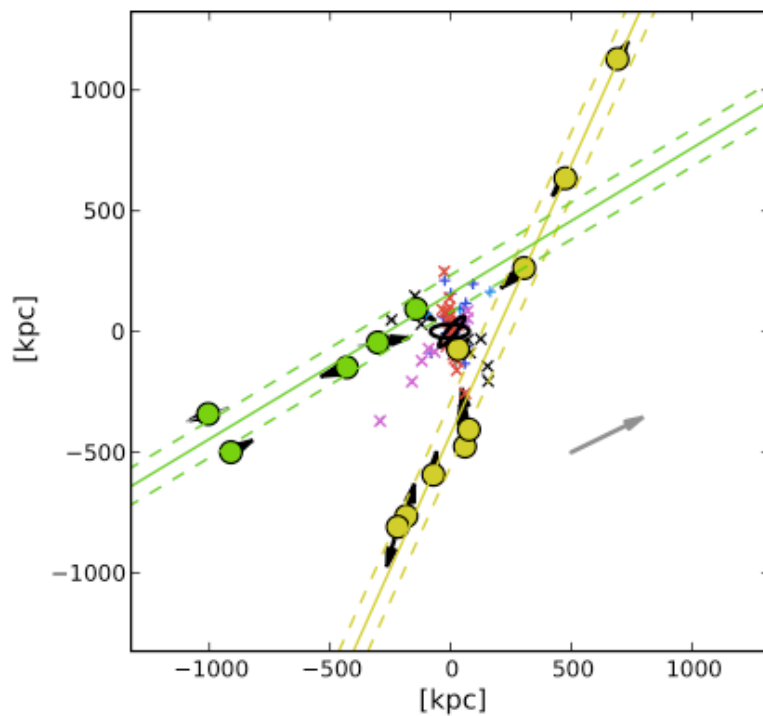
How can the MW and Andromeda satellite systems be so correlated, if they are sub-halos falling-in individually ?

42

Pawlowski, Kroupa & Jerjen (2013 MNRAS)

"*The discovery of symmetric structures in the Local Group*"

A frightening symmetry

Figure 9. Edge-on view of both LG planes. The orientation of the MW and M31 are indicted as black ellipses in the centre. Members of the LGP1 are plotted as yellow points, those of LGP2 as green points. MW galaxies are plotted as plus signs (+), all other galaxies as crosses (×), the colours code their plane membership as in Fig. 6. The best-fitting planes are plotted as

. . . the arrangement of matter in the Local Group is

totally incompatible

with the dark-matter-dominated structures.

The symmetry of the Local Group constrains the motion of

M31 relative to MW.

A
not-so local
under-density

Pavel Kroupa: University of Bonn

Measured matter density as a function of distance

Kroupa 2015

Legend:
- Keenan+ (2012)
- Keenan+ (2013), (2M++, $K_S < 14.36$)
- Keenan+ (2013), (GAMA, K<17)
- Keenan+ (2013), (UKIDSS/SDSS, K<16.3)
- Karachentsev (2012)

Y-axis: Density Contrast ($\langle \rho \rangle / \rho_0$)
X-axis: Comoving Distance (h_{70}^{-1} Mpc)
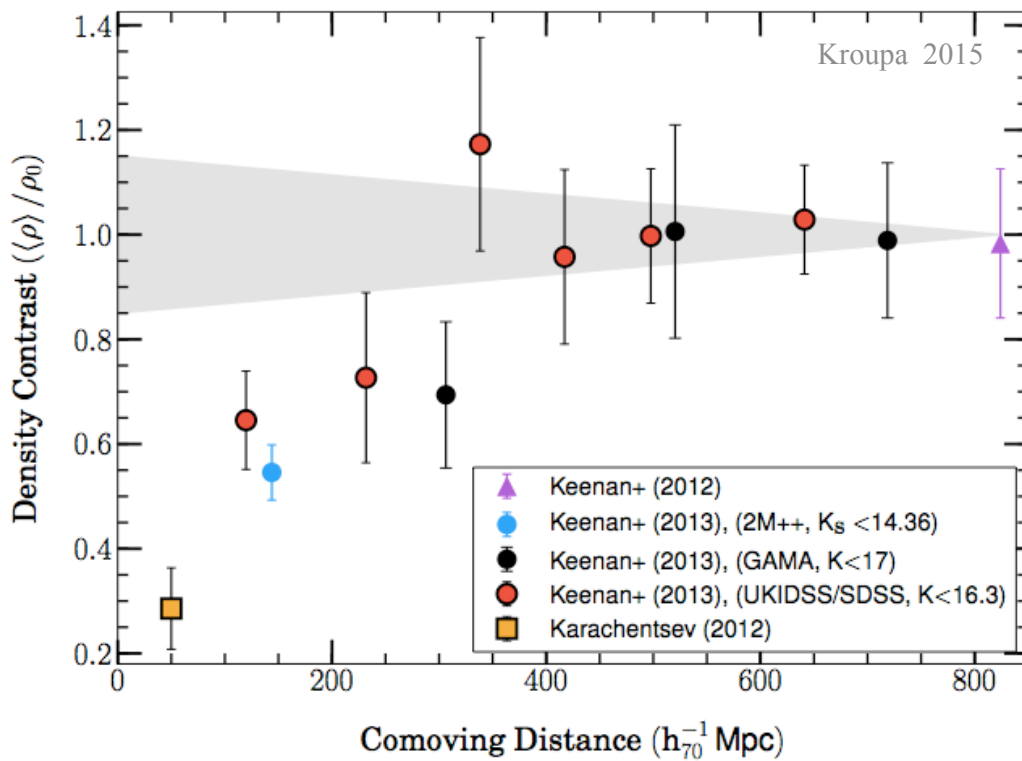
Pavel Kroupa: University of Bonn

Conclusions

All these problems rather
convincingly indicate that
dark matter particles cannot exist
such that they are dynamically
relevant.

They are in any case not part of the SMoPP
and they have not been found
directly nor indirectly.

Therefore**:** Milgromian dynamics and PoR ...

Essentially all of the above
problems are then solved trivially,

except LG symmetry and the "local" under-density.

47

Pavel Kroupa: *University of Bonn*