

# The Starivore Hypothesis:

Why the Galaxy May be Teeming with (Post)biology.



Clément Vidal

Evolution, Complexity and Cognition group,  
Vrije Universiteit Brussel  
(Free University of Brussels)

<http://clement.vidal.philosophons.com>

[clement.vidal@philosophons.com](mailto:clement.vidal@philosophons.com)



# Outline

1. Introduction
2. Criteria for Artificiality
3. Two Scales for Civilizational Development
4. Signs of Starivores?
5. The High Energy Astrobiology Prize
6. Conclusion
7. Discussion & Objections!

# 1. Introduction

Cosmological Worldview	Status
Geocentrism	Refuted
Heliocentrism	Refuted
Galactocentrism	Refuted
Biocentrism	Still true
Intellicentrism	Still true
Universecentrism	Still true

# How old could extraterrestrials be?

- Maximum age of extraterrestrial intelligence:
  - 7.5 billions years our senior [Dick \(2009b, 467–468\)](#)
  - 1.8 billions years our senior on average  
[\(Lineweaver 2001; Lineweaver, Fenner, and Gibson 2004\)](#)
- We should not be afraid to speculate!

## 2. CRITERIA FOR ARTIFICIALITY

Two methodological fallacies

Zen SETI

The Case for Postbiology

Global Criteria

Thermodynamical Criteria

Living Systems Criteria

# Artificiality-of-the-gaps

**Definition:** Unless proven otherwise, assume phenomena to be of **artificial** origin



- Theoretical foundations of Ufology
- Fallacy!
- “We observe something strange, therefore it is an alien”.
- Error not to explore and consider the existing “natural explanations”.

# Naturality-of-the-gaps

**Definition:** Unless proven otherwise, assume phenomena to be of **natural** origin



- Theoretical foundations of scientific SETI (Shklovsky 1971). Endorsed by Sagan and Dyson.
- Everything, the living and the non-living must obey physical laws. Trivial! Actually against artificiality-of-the-gaps.
- Fallacy!
- “Unless proven otherwise, assume the Earth is at the center of the universe”
- **Key question:** *on which conditions will we give up modelling the phenomenon as natural, and conclude that it must be artificial?*



We need criteria to discriminate  
between natural and artificial!

# Astrobiological Stance

Interpretation --> Interception	Positive	Negative
Extraterrestrial	True positive (good science)	False negative (naturalness-of-the-gaps)
Other	False positive (artificiality-of-the-gaps)	True negative (good science)

- **Definition:** unless proven otherwise, assume phenomena to be of either **natural or artificial** origin.



# Zen SETI

*Sometimes I think the surest sign that intelligent life exists elsewhere in the universe is that none of it has tried to contact us.*

Bill Watterson, cartoonist of *Calvin & Hobbes*.

# Take the Zen SETI path and abandon:

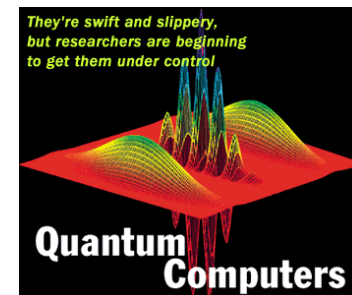
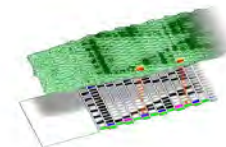
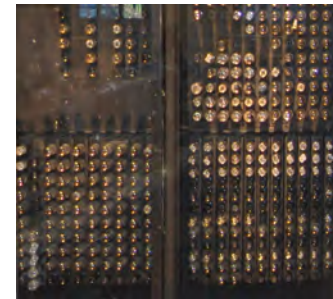
- ETIs want to communicate (cf Calvin)
  - Orthodox SETI assumption
  - ETIs living in our galaxy only
  - ... and there are 170 billions galaxies!
- ETIs use oxygen, carbon, etc.
- ETIs live on a planet around a sun-like star
- ETIs thrive on Earth-like temperatures/magnetic fields

**Note:** broadening the search space makes sense for searching **advanced** extraterrestrials, less for traditional astrobiology.

# The Case for Postbiology

**5 changes in computational substrate in less than 100 years!**

- Electromechanical calculators
- Relay-based
- Vacuum tubes
- Transistors
- Integrated circuits
- 3D molecular computing
- Quantum computers (...patience!)



# Global Criteria (heuristic)

- **Strangeness heuristic:**  
*Advanced extraterrestrials manifestations will not be easy to model.*  
*(necessary, but not sufficient)*
- **The inverse distance-development principle:**  
*“the more distant,  
the less developed we expect”*  
(Kardashev 1997)

# Thermodynamical Criteria

- Equilibrium / Dissipative / Living
  - E.g.: stone / wild fire / animal
- **Energy flow control:** *a necessary condition for the growth, maintenance, evolution and reproduction of complex systems*  
(e.g. [Aunger 2007b](#); [Chaisson 2011a](#))
- **Metabolic criteria:** *energy flow control, dissipation of entropy.*

# Living Systems Criteria (Miller 1978)

Matter + Energy + Information	Matter + Energy	Information
1. Reproducer	2. Boundary	11. Input transducer
	3. Ingestor	12. Internal transducer
	4. Distributor	13. Channel and net
	5. Converter	14. Decoder
	6. Producer	15. Associator
	7. Matter-energy storage	16. Memory
	8. Extruder	17. Decider
	9. Motor	18. Encoder
	10. Supporter	19. Output transducer

### **3. TWO SCALES FOR CIVILIZATIONAL DEVELOPMENT**

Kardashev  
Barrow

# Civilizational Development

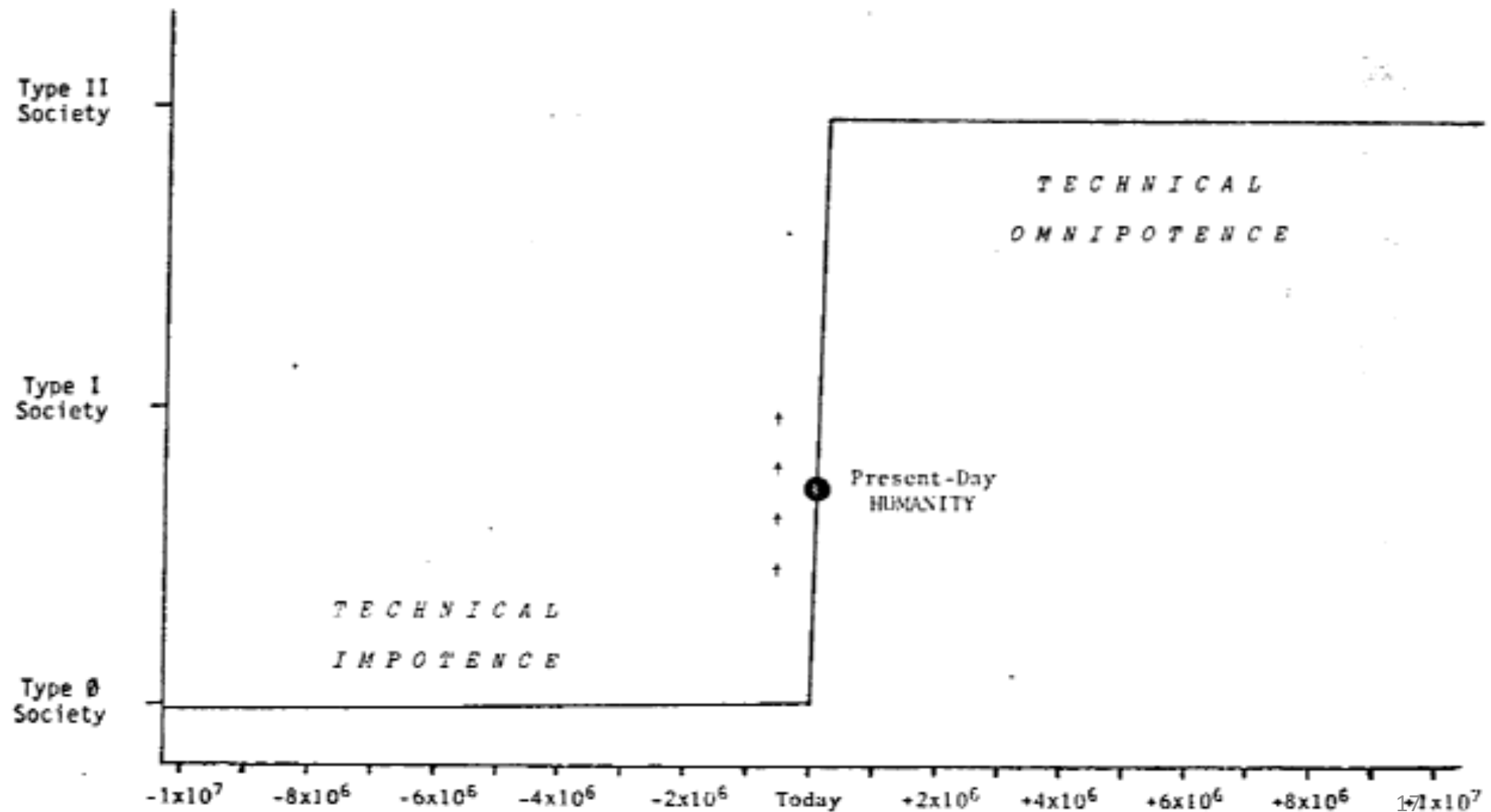


Kardashev Scale			Barrow Scale		
KI	– energy consumption at	$\sim 4 \times 10^{19} \text{ erg.s}^{-1}$	BI	– manipulates objects of its own scale	$\sim 1 \text{ m}$
KII	– energy consumption at	$\sim 4 \times 10^{33} \text{ erg.s}^{-1}$	BII	– manipulates genes	$\sim 10^{-7} \text{ m}$
KIII	– energy consumption at	$\sim 4 \times 10^{44} \text{ erg.s}^{-1}$	BIII	– manipulates molecules	$\sim 10^{-9} \text{ m}$
			BIV	– manipulates individual atoms	$\sim 10^{-11} \text{ m}$
			BV	– manipulates atomic nuclei	$\sim 10^{-15} \text{ m}$
			BVI	– manipulates elementary particles	$\sim 10^{-18} \text{ m}$
			BΩ	– manipulates space-time's structure	$\sim 10^{-35} \text{ m}$

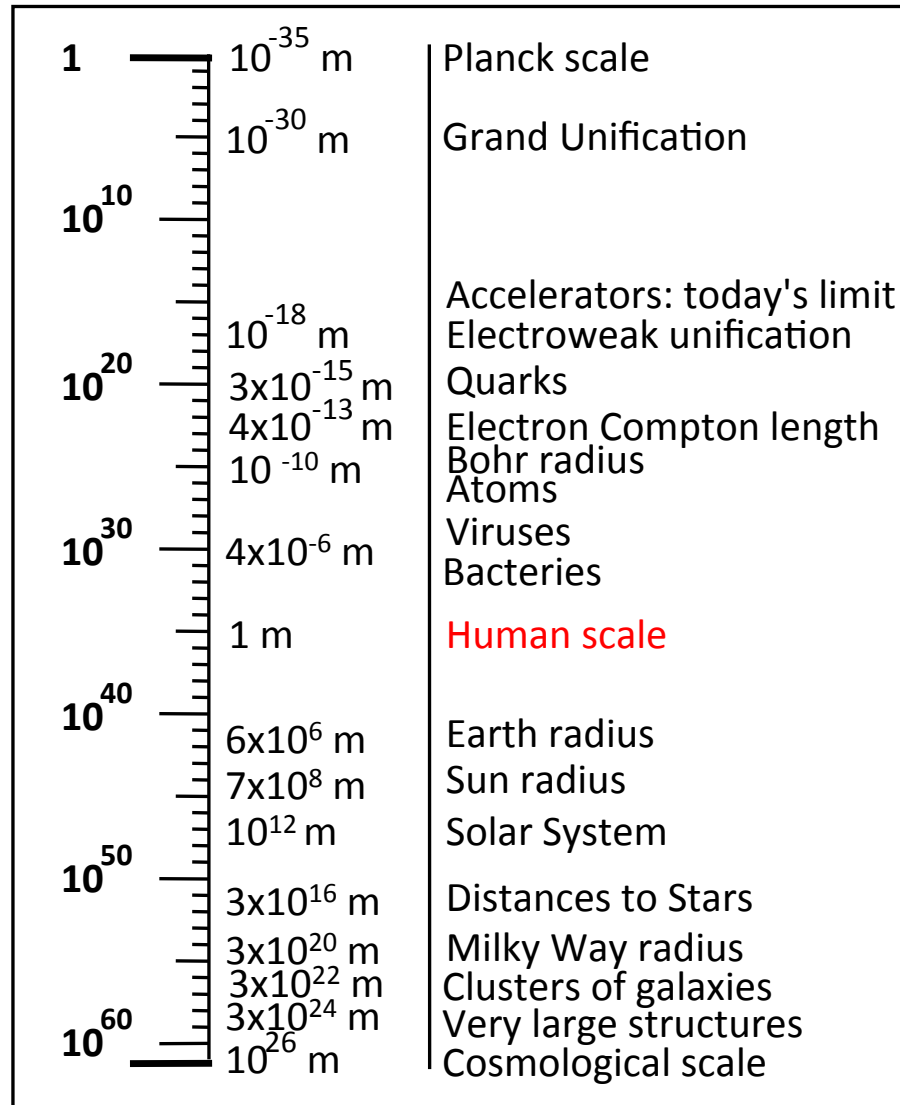
- Still Zen SETI:  
energy and scale are universal parameters.



# Kardashev Type II: our next energetic phase transition?



# Barrow Scale: Colonizing *inner* space



- “there is plenty of room at the bottom”.  
(Feynman 1960)
- “there is more to explore in small scales than in large scales.”  
(Vidal 2011) See also (Smart 2012)

# 4. SIGNS OF STARIVORES?

The Binary Zoo

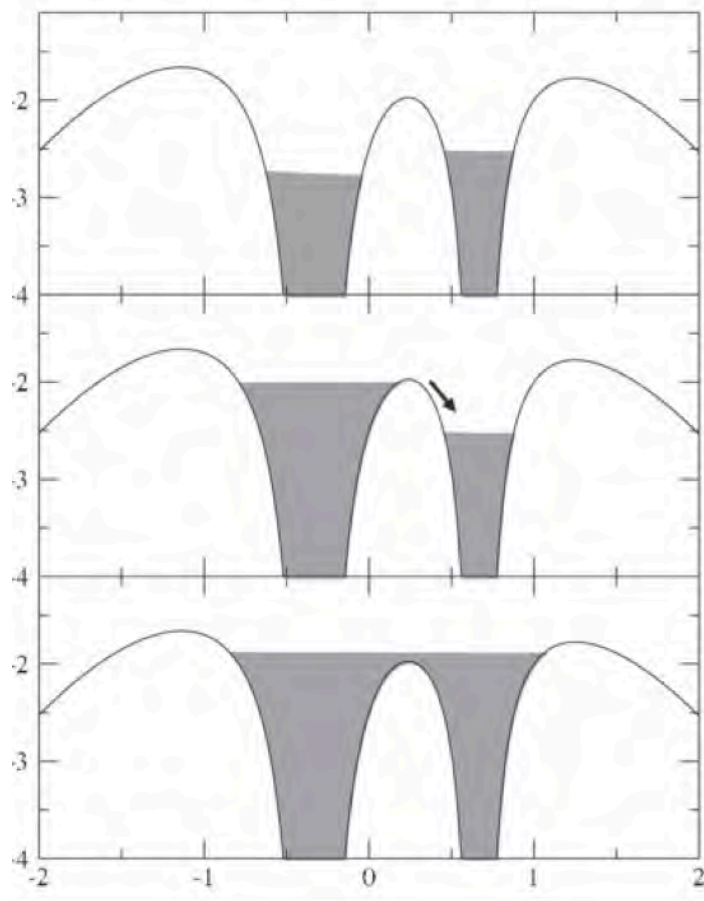
Thermodynamical Arguments

Living Systems Arguments

Binary Pulsars

# The Binary Zoo

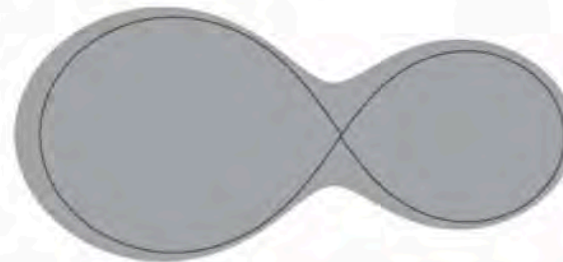
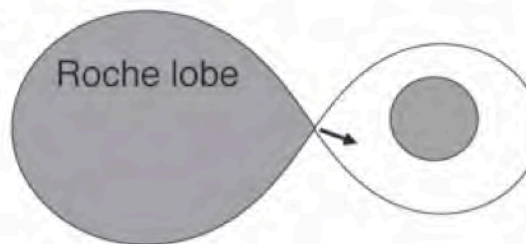
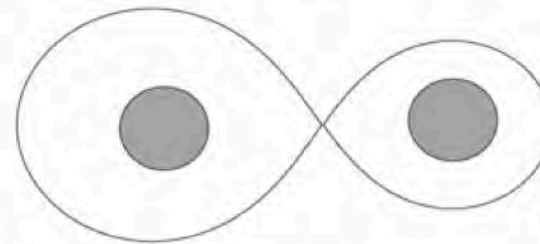
Similar to  
different  
thermodynamical  
systems:



detached

semi-detached  
mass transfer  
(RLOF)

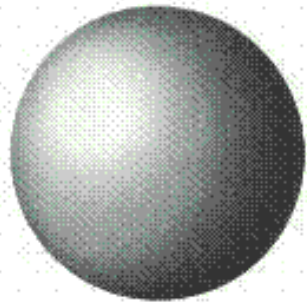
common  
envelope



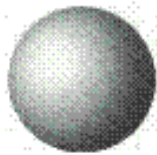
Two stones

Living?

Wild fire



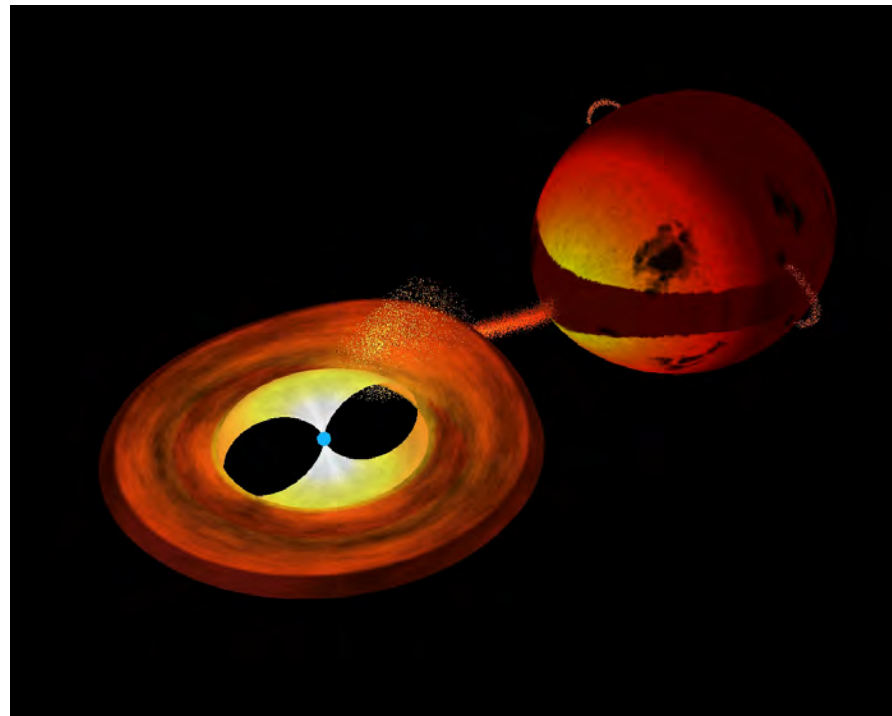
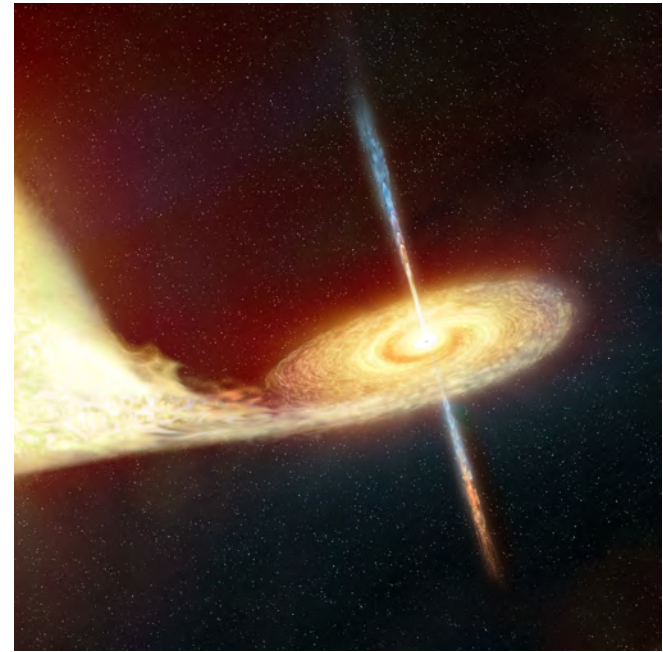
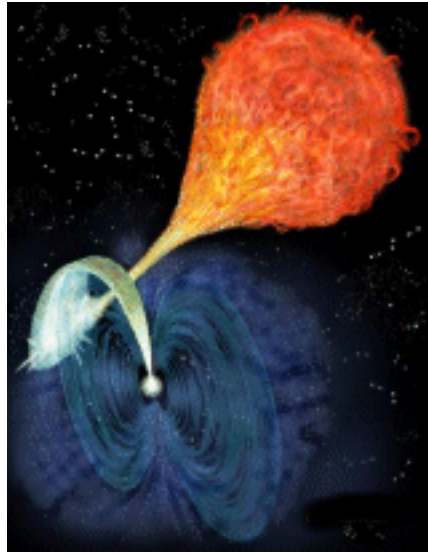
EARTH

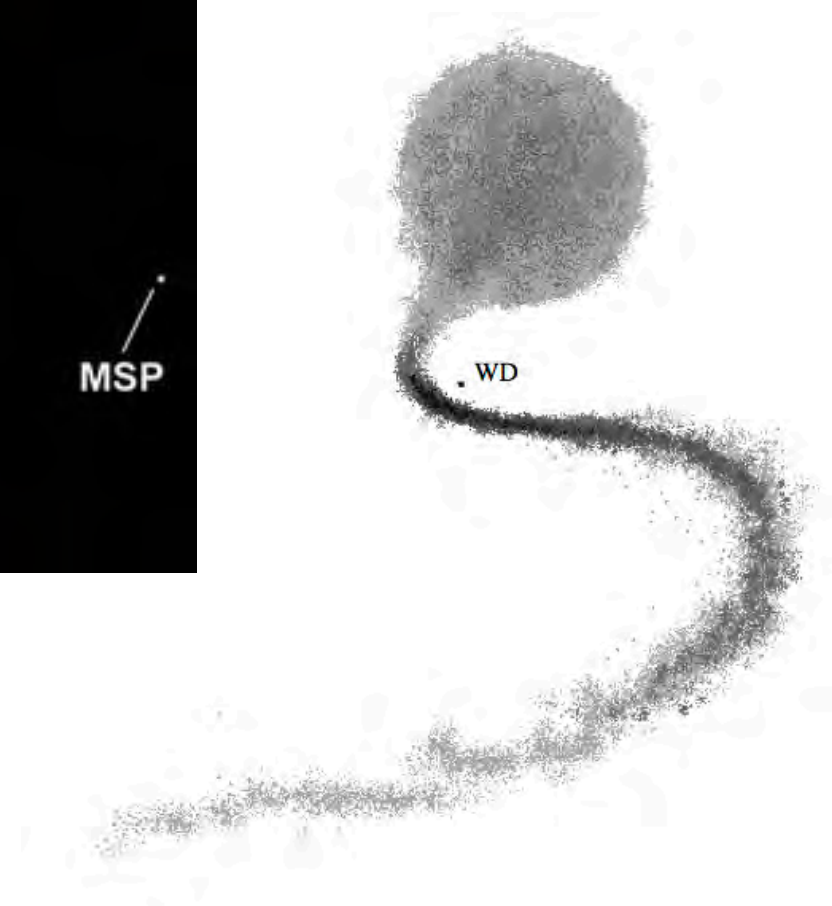
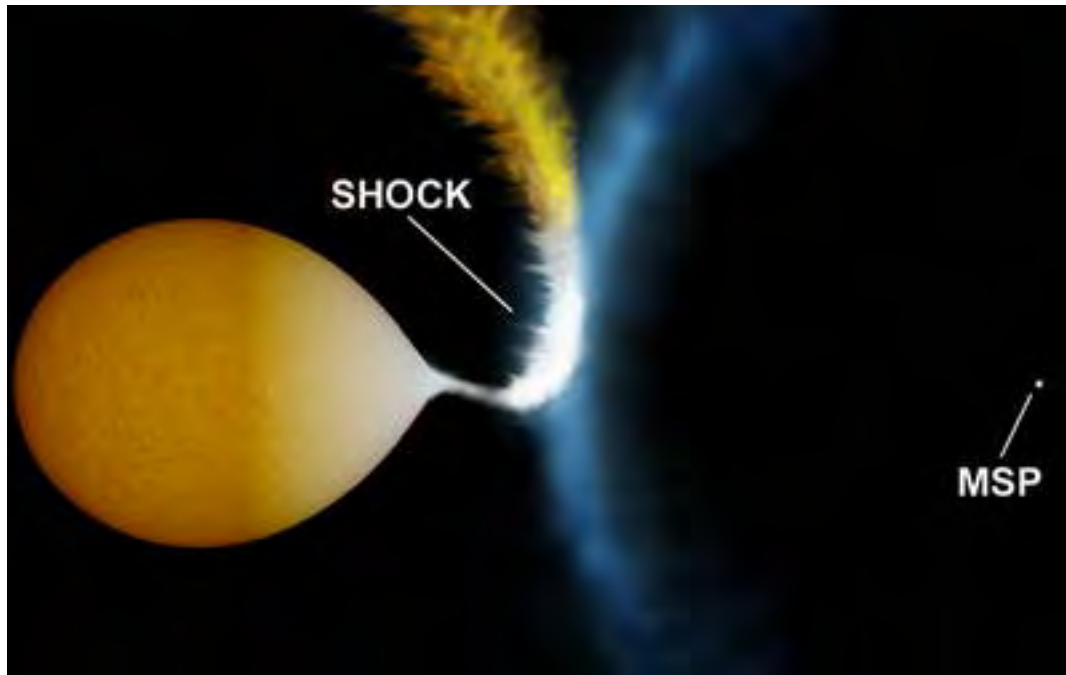


WHITE DWARF



NEUTRON STAR





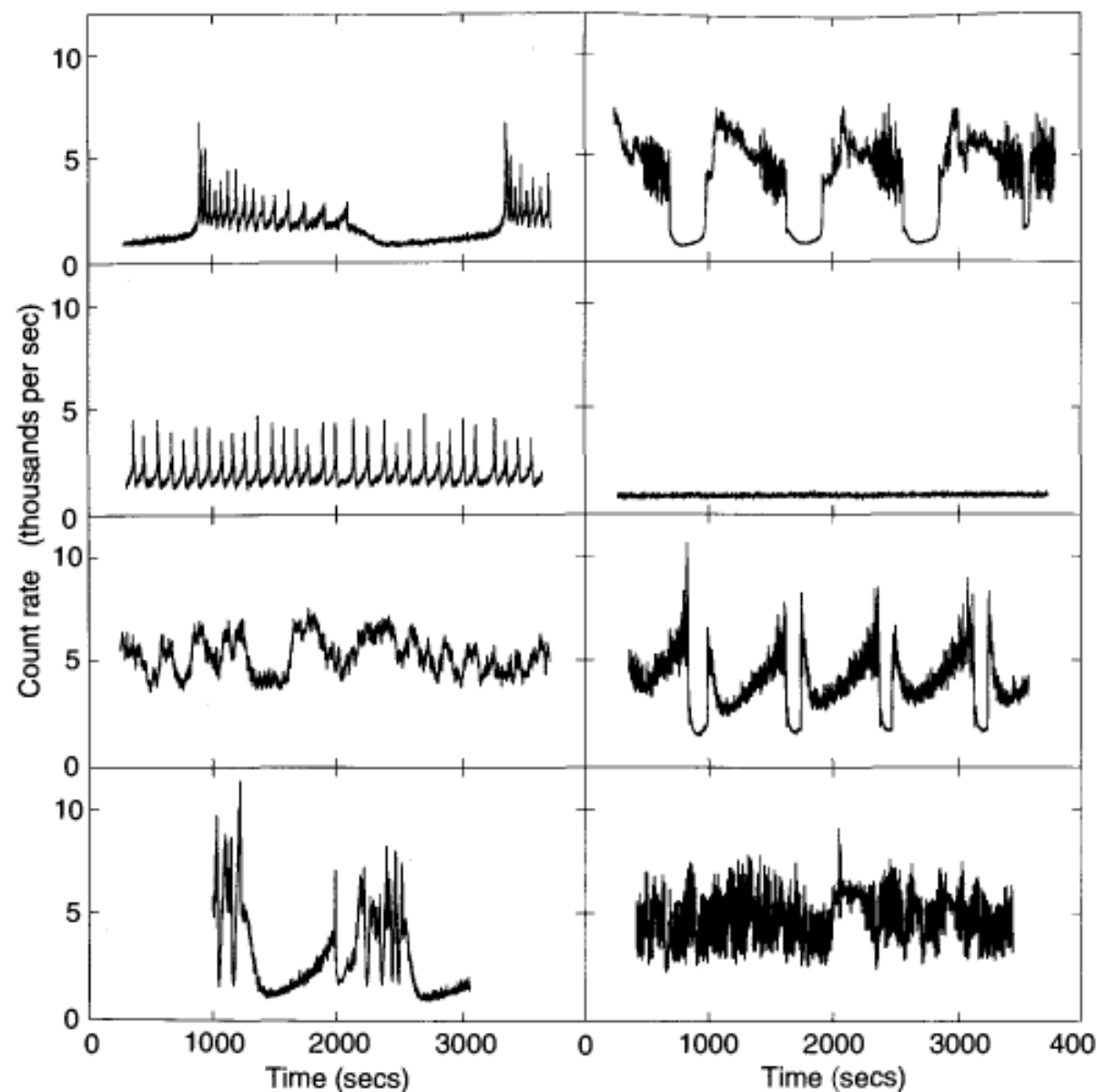


Fig. 13.5: A sample of the X-ray lightcurves of GRS 1915+105, obtained with the *RXTE* satellite in the 2–30-keV band. All the plots are on the same scale, and illustrate the astonishing range of behaviour this one star exhibits. (Based on work by Michael Muno, Edward Morgan & Ronald Remillard.<sup>5</sup>)

# Thermodynamical arguments

- Accretion rate is varying in a subset of semi-detached binaries; i.e. energy flow control?
- Entropy is expelled in novae (white dwarfs) or jets (neutron stars and black holes)
  - Novae ejectas have a different chemical composition from the accreted matter (Prialnik 2001).  
Is there work done between accretion and ejection?
- Anomalously high “energy rate density”



# Putative Starivores Illustrated

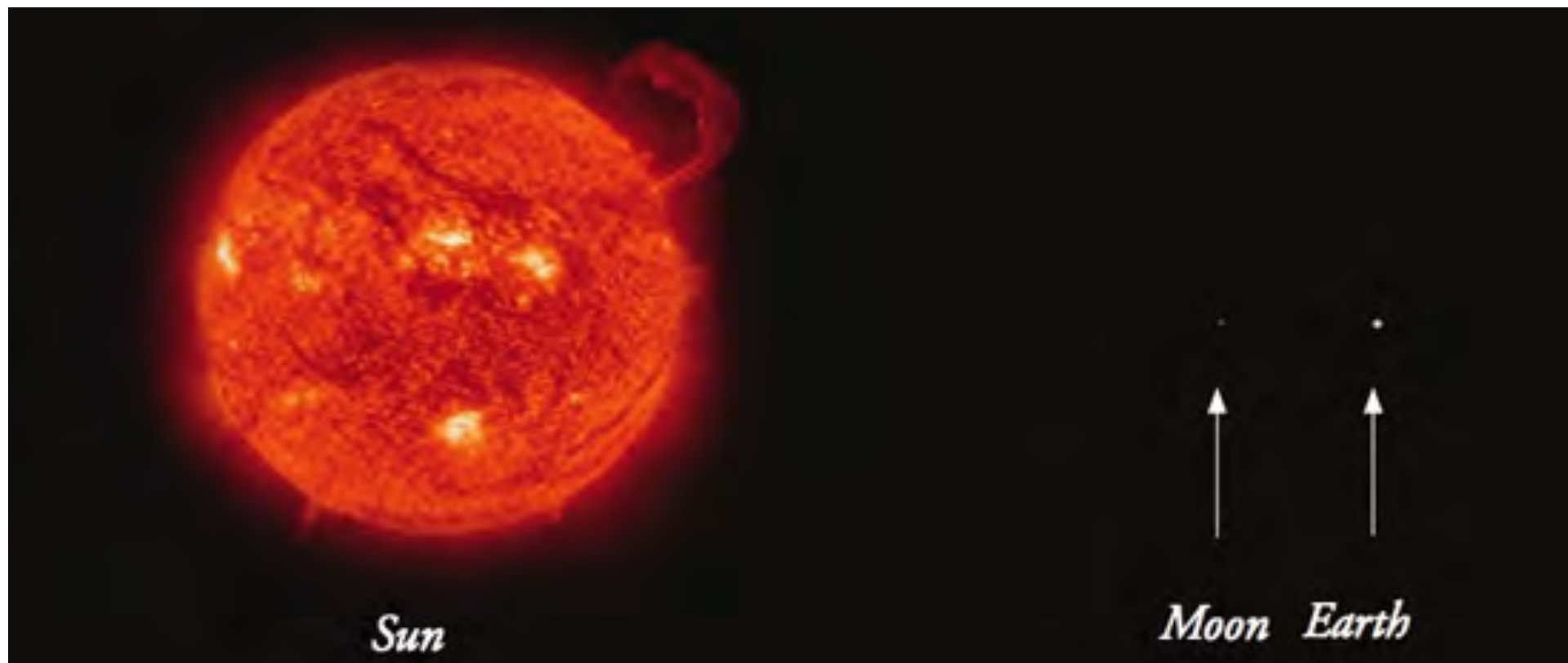


# What is a starivore?

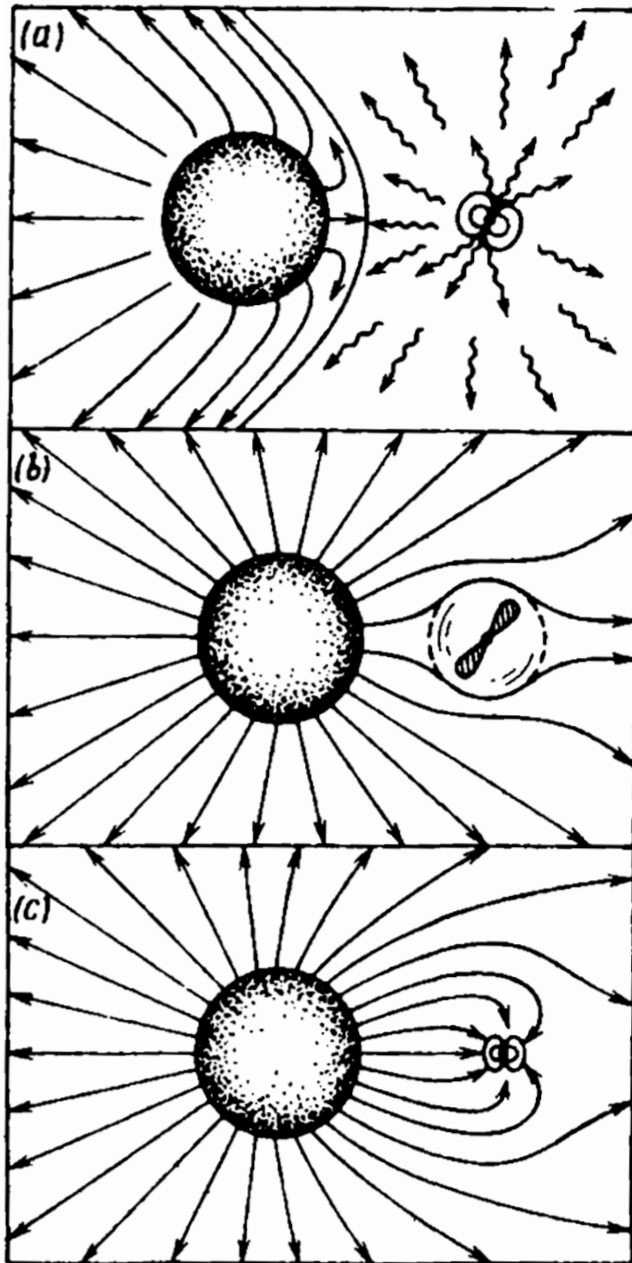
- **Definition 1** : an extraterrestrial civilization
  - using stellar energy  
(type KII on Kardashev's scale),
  - in the configuration of a slow non-conservative transient accreting binary  
(thermodynamic criteria),
  - with the dense primary (Barrow scale) being either a WD, a NS or a BH.
- **Definition 2**: a civilization that feeds actively on stars.







# Living Systems Arguments



## High Energy Astrophysics

(a) an ejecting pulsar

From (Lipunov 1989, 173).

(b) a “propeller”

(c) an accreting neutron star.

## High Energy Astrobiology

(a) *extruder* function

(b) *motor* function

(c) *Ingestor* function.

# Tentative Living Systems Interpretation

- 5. Converter
  - Conversion of energy extracted from the secondary, for changing the orbit, changing the rotation; increasing the magnetic field; regulating the accretion flow or maintaining an hypothetical internal organization.
- 7. Matter-Energy storage
  - Matter-energy storage in binaries is mainly in the accretion disc. The disc could act as an energy buffer. However, energy can also be stored in the rotation of the dense component, or in its sheer mass.

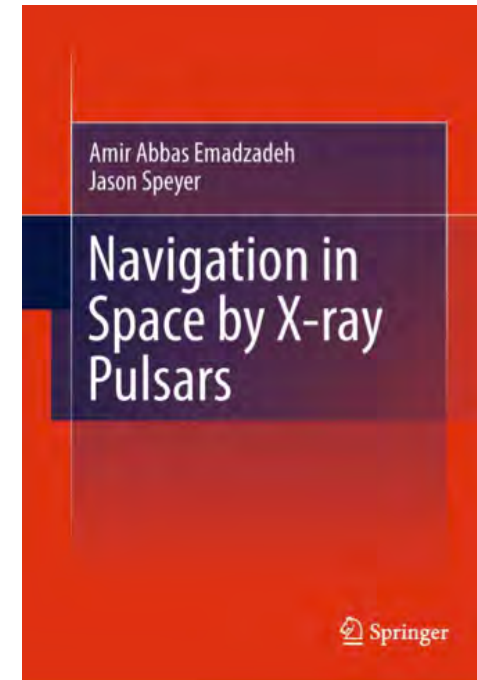
# Summary:

## Living Systems Arguments

Matter + Energy + Information	Matter + Energy	Information
1. <b>Reproducer:</b> Cosmological Artificial Selection (Vidal 2013, PhD, Chap 8)	2. <b>Boundary</b>	11. Input transducer
	3. <b>Ingestor</b>	12. Internal transducer
	4. Distributor	13. Channel and net
	5. <b>Converter</b>	14. Decoder
	6. Producer	15. Associator
	7. <b>Matter-energy storage</b>	16. Memory
	8. <b>Extruder</b>	17. Decider
	9. <b>Motor</b>	18. Encoder
	10. Supporter	19. Output transducer

# Binary Pulsars

- What about informational subsystems?
- If you prepare a galactic trip and need to navigate at relativistic speeds and keep track of time, use X-ray pulsars and this guidebook:
- Pulsars need to be re-assessed:
  - flash on and off for long periods (*pulse nulling*)
  - switch between frequencies (*mode changing*).
  - *giant pulses*
  - *pulse microstructure , etc.*  
(see e.g. Manchester 2009 for a review).






# 5. The High Energy Astrobiology Prize

Project	Type
Gamma-ray bursts and binaries	robustness
Kleiber's law extended to astrobiological scales	biological scaling law
Scale relativity and binaries	galactic and extragalactic distribution
Pulsars decoding	information, navigation, messages



# 6. Conclusion

- Two independent arguments for the existence of starivores:
  - Two scales extrapolation: energy use and small scale / high density technology
  - Thermodynamical, metabolic, living systems aspect of some binary systems.
- The jury is still out. And we are the jury.  
Research, criticize, vote, propose new ideas, or  to test the existence of advanced extraterrestrials.



<http://www.highenergyastrobiology.com/theprize.htm>

# Thank you for your attention!

Questions, suggestions and critiques  
are welcome now or later:

[clement.vidal@philosophons.com](mailto:clement.vidal@philosophons.com)

- **More information:** Vidal, C. 2013. “The Beginning and the End: The Meaning of Life in a Cosmological Perspective”. 360 pages, PhD preprint, Brussels: Vrije Universiteit Brussel.  
<http://scan.me/54qlz1>

# 7. Objections and Questions

- Is it new? No!
  - Stapledon (SF)
  - Beech (2008)
- What about astrophysics? Can't it already explain binary stars evolution?
  - No, I did not dispose of Occam's razor.
  - There are many open questions, and binaries can be extremely difficult to model.
  - Nova ejecta: display heavy elements abundances
  - Accretion disc viscosity (factor one billion discrepancy between model and observation)
  - Accretion rate can vary by 2 or 3 orders of magnitude in otherwise similar systems! (Hellier 2001, 171)

# How many putative starivores are out there?

- CV: 1826 (in 2006:  
<http://archive.stsci.edu/prepds/cvcat/stats.txt> )  
but not all CVs are ETI candidates.
- XRB: 429 (but some are WD, and may overlap with CVs catalogs; see [Caballero and Wilms 2012](#));
- Pulsars: 1500 known; most pulsars are single; 25 extragalactic. ([McLaughlin and Cordes 2003](#)).
- Microquasars: about 20 known (1 extragalactic: XMMU J004243.6+412519 in Andromeda Galaxy (M31)).

**Maybe about 2000 known starivores.**

# Dyson Spheres VS Starivores!

## Dyson Sphere

- Anti-Barrow scale (huge structure)
- Passive energy extraction
- No observational counterpart despite searches (excluding Star Wars).



## Starivore

- Barrow scale
- Active energy extraction
- Observed

# Will we become starivores?

Let's get into a stellar diet in 5 “easy” steps:

1. Switch fully to solar energy
2. Climb Kardashev's and Barrow's scales
3. Change Earth's orbit to get closer to the Sun to extract more of its energy (postbiology)
4. Start to feed actively on the Sun with strong magnetic fields
5. Welcome to the club!

# Where is starivores' missing mass?

- We observe putative systems of at least second generation, having already migrated to a new star
- Planetary accretion is a prediction of the starivore hypothesis, and planet-star interactions have recently been discovered, (Lecavelier des Etangs et al. 2012)



# The Candle Objection

Objection:

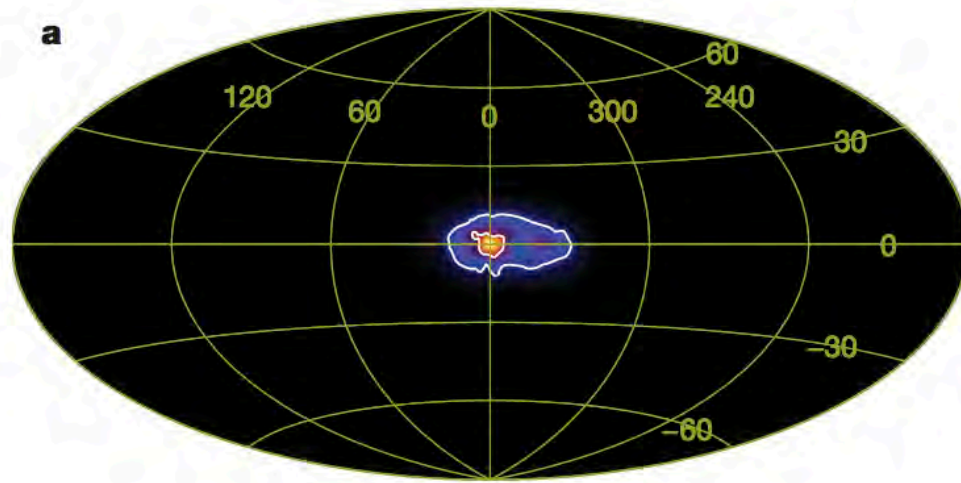
“Your arguments are weak. A candle has also a metabolism”

My answer:

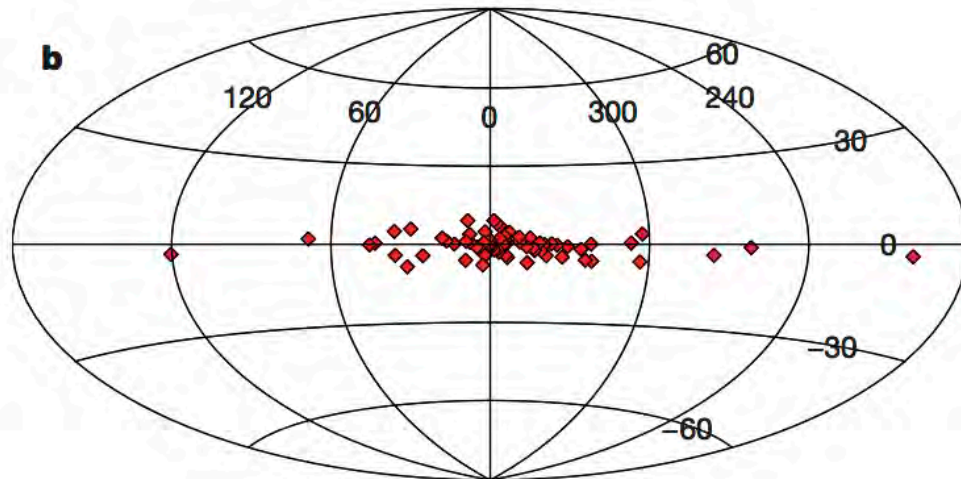
Indeed, a candle has a minimal metabolic activity. But it lacks:

- Energy flow control
- Living systems properties

# Do starivores have a sexuality?



.... Maybe



Cosmological Sexual  
Selection to improve  
Cosmological Artificial  
Selection?

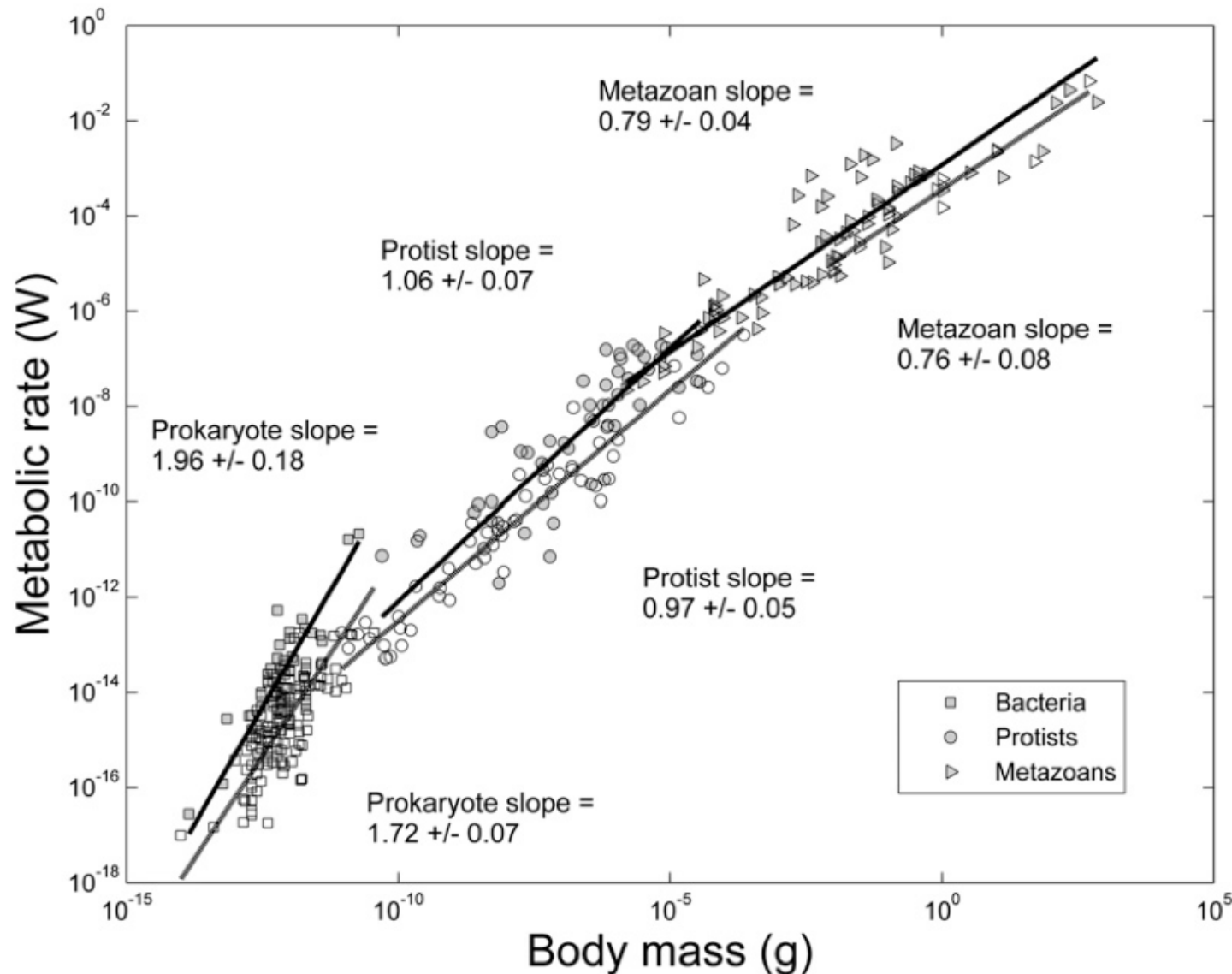
I leave this question for  
next generations...

# Four research proposals entitling to the High Energy Astrobiology Prize

# (1) Gamma-ray bursts and binaries

- Are starivores protected from gamma-ray bursts?
  - Violent events which could wipe out eukaryotes in a range of 14 kpc from the explosion (see Scalo and Wheeler 2002; and also Ćirković, Vukotić, and Dragićević 2009).
- How can we protect ourselves from cosmic radiation?
  - One natural solution we already have to protect ourselves from the Sun's dangerous radiation is the Earth's natural magnetic field ( $\sim 0.45$  Gauss) which deviate most of it.
  - Now, could a higher magnetic field protect from gamma-ray bursts? We can speculate that the extremely high magnetic fields observed in binaries (e.g.  $10^3$ - $10^9$  Gauss for white dwarfs) would make the binary immune to such catastrophes. Is it the case?

## (2) Kleiber's law extended to astrobiological scales?



# (3) Scale Relativity and Binaries

- Scale relativity gives probabilities to have single, double, triple or n-body systems. Preliminary results explain why pairs of galaxies are so common (L. Nottale 2011, 654–658).
- This project consists in applying scale relativity to the formation of binary systems. If binaries are starivores, the prediction of scale relativity should fail.
  - Indeed, we should find more binary systems than what would be formed by natural gravitational formation. Or there should be proportionally less pairs of galaxies than binary systems. Note that the picture could be more complicated if putative starivores migrate and leave single depleted stars.
- Furthermore, applying the inverse distance-development principle, further and further away galaxies should fit more and more the predictions of scale relativity.
- What do we expect? A study of the distribution of binary systems in our galaxy and possibly in others.
- If it succeeds, we would **have an estimate of the number of intelligent civilizations in the galaxy**, simply by subtracting the observed number of binaries with the predicted number.

## (4) Pulsars decoding

- A convincing proof of ETI should include information processing. This is why I insisted that the assessment of whether there are messages in pulsars should be a priority (see Vidal 2013 PhD, section 9.4.6 Are Pulsars Artificial Output Transducers?).
- There is a lot of new research in pulsars, and the pulses display an impressive array of behavior, not obvious to explain with "natural explanations".  
Decoding an extraterrestrial message is probably an amazingly difficult task.
  - a first easier step is to assess if pulses display informational complexity (e.g. according to Kolmogorov complexity or Bennett's logical depth). Pulsars signals could be benchmarked against "natural" signals (e.g. sea waves) and "artificial" signals (e.g. wifi). If they score like sea waves, they are more likely natural; if they score like wifi signal, they are more likely artificial. Again, corroboration or refutation are entitling to the prize.
- Pulsars might also constitute an artificial galactic navigation system. Emadzadeh and Speyer (2011) recently showed that absolute and relative navigation is possible thanks to X-ray pulsars. It is indeed not at all a trivial matter when you navigate at a significant portion of the speed of light to keep track of time, because of the time-dilation and contraction effects predicted by relativity theory. Finding typical features of an artificial navigation system is entitling to the prize.

# 8. References

- All cited references and more are available in:
- Vidal, C. 2013. “The Beginning and the End: The Meaning of Life in a Cosmological Perspective”. PhD preprint, to be defended, Brussels: Vrije Universiteit Brussel.  
<http://scan.me/54qlz1> (latest version)  
<http://arxiv.org/abs/1301.1648>
- Except:
  - Caballero, I., and J. Wilms. 2012. “X-ray Pulsars: a Review.” arXiv:1206.3124 (June 14).  
<http://arxiv.org/abs/1206.3124>.
- Acknowledgments: John Smart, Georgi Georgiev, Tobias Kerzenmacher for great discussions

**The Beginning and the End:**  
The Meaning of Life in a Cosmological Perspective

