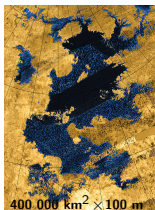# Modeli galaktičke nastanjivosti

Branislav Vukotić

Astronomska opservatorija u Beogradu

bvukotic@aob.rs
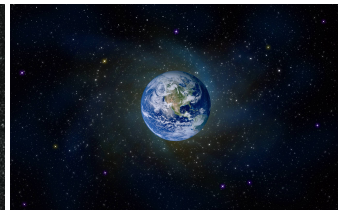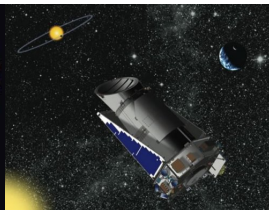
Seminar Katedre za astronomiju

10.03.2015.

Nastanjivost

Očekivano sletanje 2040.

400 000 km^2 ×100 m
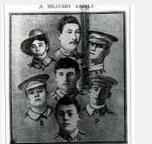

$\times$
10^6 !!!

监视相机C图像
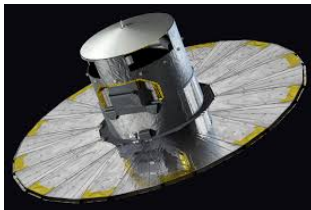
Bitno za nastanjivost

Zvezdani sistem:
- Višestrukost
- Masa zvezde
- Broj i položaji planeta
- Stabilnost orbita
- Mase i sastav planeta
- Skupine malih tela
- Interakcija sa drugim sistemima, razmena materijala

Galaksija:
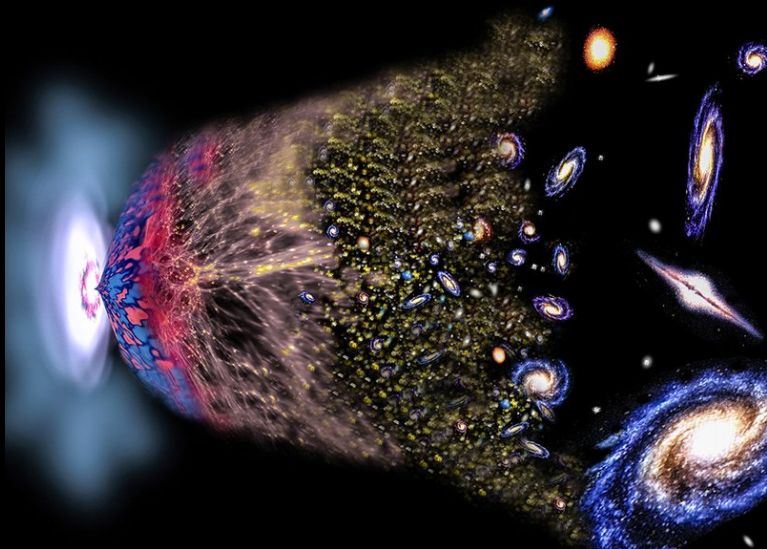- Metaličnost
- Gustina
- Zračenja
- Mešanje populacija

Zašto da modeliramo baš to?

Izgleda da je važno!

Kosmološka paralela

Početak $\xrightarrow[kontinuitet]{evolucija}$ Seminar 10 mart 2015, kao sasvim običan seminar bilo gde u svemiru.

Kontinuitet

This common element, which I will coin "the continuity thesis", is the assumption that there is no unbridgable gap between inorganic matter and living systems, and that *under suitable physical conditions the emergence of life is highly probable*. It is the adoption of the "continuity thesis", concerning the philosophical dimension of life-matter relationship, which has turned the origin of life into a legitimate scientific question, and which constitutes a necessary condition for any scientific research in this domain.
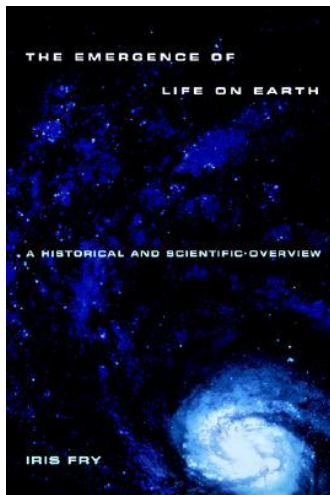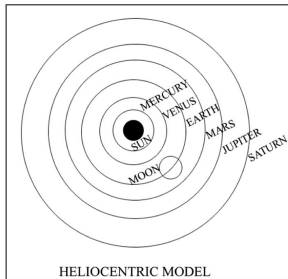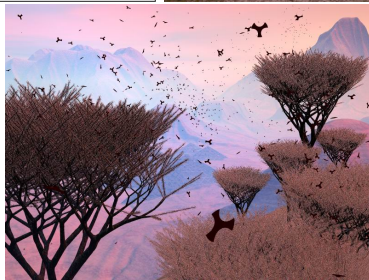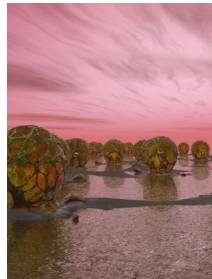
Ništa posebno, mada tako ne izgleda.
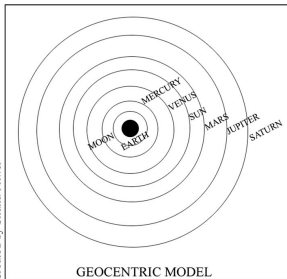
Idila...

Idila...?

Uticaj neočekivanog
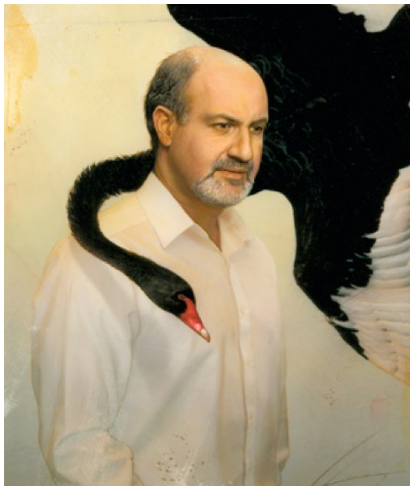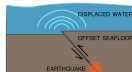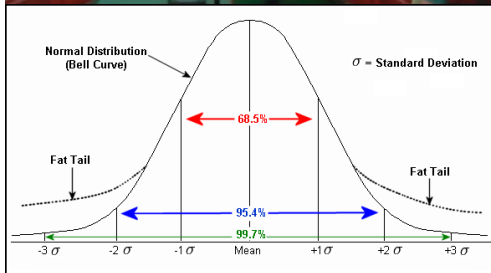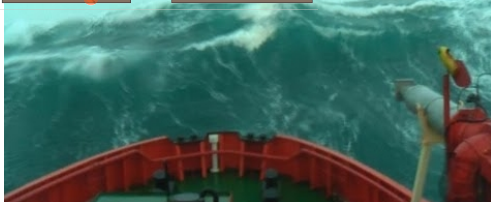
Obrenovac, maj 2014.

Analitički $\longrightarrow$ Katastrofa.

Katastrofa $\xrightarrow{\text{Monte Carlo simulacije}}$ Katastrofizam
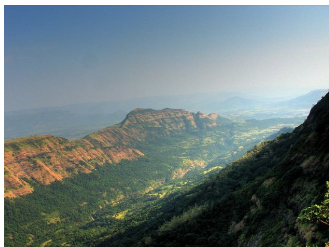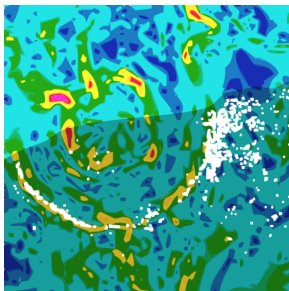
Punctuated equilibrium

Postepena ekstinkcija?

Signor-Lipps Effect
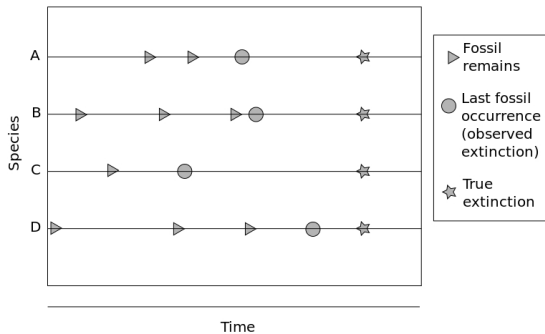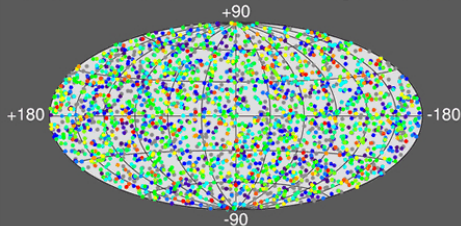
Šta se dogodilo pre ∼ 65 Myr?

Katastrofični događaji na galaktičkoj skali
Funkcija globalnog rizika

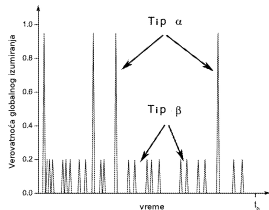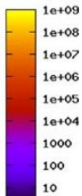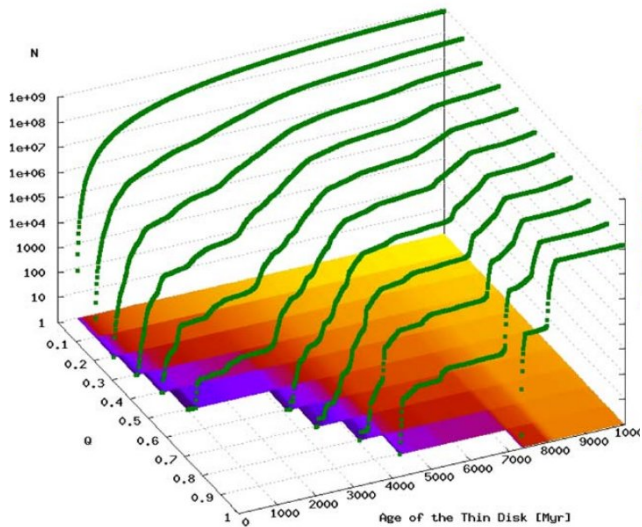- γ-bleskovi:
  - Annis J, 1999, JBIS, 52, 19.
  - Scalo, J., Wheeler, J.C., 2002, ApJ, 566, 723.
  - Thomas, B.C. et al, 2005, ApJ, 634, 509.

- Supernove

- Sudari zvezda

Način modeliranja
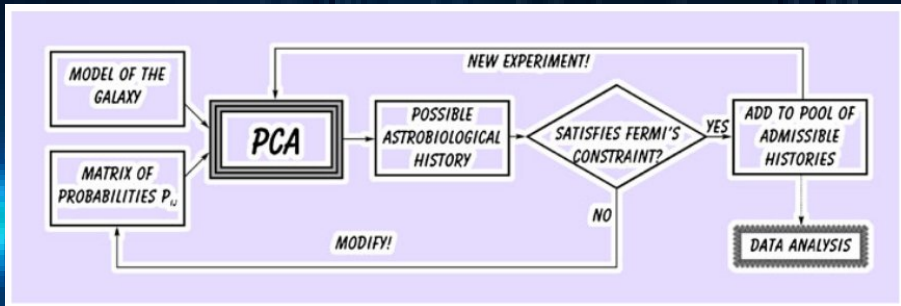
1D model: Primer korelisanja vremenske skale

Veoma kraaaaaaatak uvod u EĆA

Uređena četvorka: $\{G, S, N, F\}$

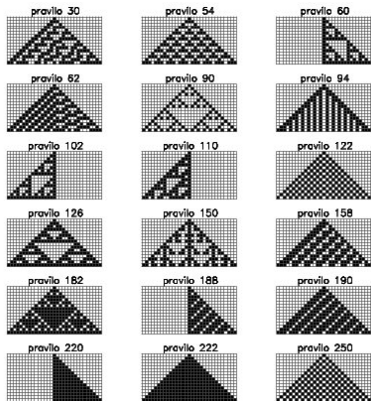$$f : S^{2r+1} \rightarrow S,$$

$$|F| = m^{m^{2r+1}}.$$

$$s_i^{(t)} = F(s_{i-r}^{(t-1)}, s_{i-r+1}^{(t-1)}, ..., s_{i+r-1}^{(t-1)}, s_{i+r}^{(t-1)}).$$
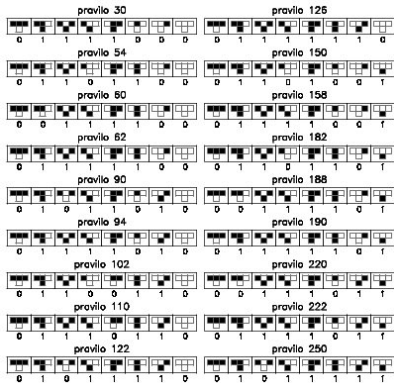
$$s_i^{(t)} = F(s_{i-r}^{(t-1)}, s_{i-r+1}^{(t-1)}, ..., s_{i+r-1}^{(t-1)}, s_{i+r}^{(t-1)},$$

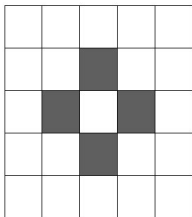$$s_{i-r}^{(t-2)}, s_{i-r+1}^{(t-2)}, ..., s_{i+r-1}^{(t-2)}, s_{i+r}^{(t-2)},$$

$$\vdots$$

$$s_{i-r}^{(t-n+1)}, s_{i-r+1}^{(t-n+1)}, ..., s_{i+r-1}^{(t-n+1)}, s_{i+r}^{(t-n+1)},$$

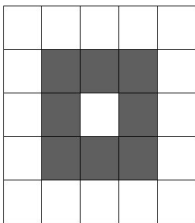$$s_{i-r}^{(t-n)}, s_{i-r+1}^{(t-n)}, ..., s_{i+r-1}^{(t-n)}, s_{i+r}^{(t-n)})$$
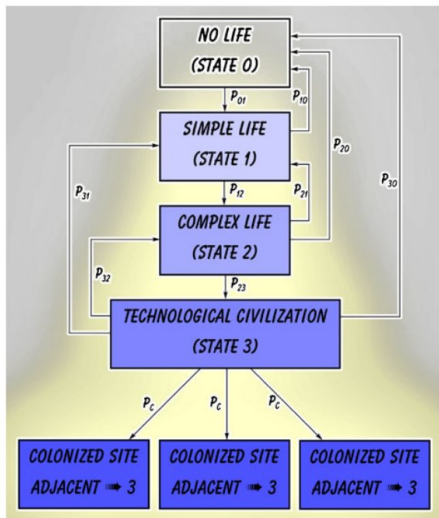
.

Neki EĆA

Conus textile

# 2D ĆA i PĆA

von Neumann

Moore

Ispitivanje parametarskog prostora: Kratko uputstvo

```
/*ako je f=1
onda se verovatnoca menja inace se ne menja
ako je f=0 - tad se uzimaju u obzir
samo vreme1 i stdev*/

b f X Y Z stdev  vreme1 korak  vreme2
0 0 0 1 0 1.0E09 1.0E09
1 0 1 2 0 1.0E09 3.0E09
2 0 2 3 0 0.1E09 0.2E09
3 1 3 2 0 0.1E09 0.2E09 0.1E09 0.5E09
4 1 2 3 0 0.1E09 0.2E09 0.1E09 0.5E09
5 0 2 3 4 0.1E09 0.2E09

1.000000e+09 3.000000e+09 2.000000e+08 2.000000e+08 2.000000e+08 2.000000e+08
1.000000e+09 3.000000e+09 2.000000e+08 2.000000e+08 3.000000e+08 2.000000e+08
1.000000e+09 3.000000e+09 2.000000e+08 2.000000e+08 4.000000e+08 2.000000e+08
1.000000e+09 3.000000e+09 2.000000e+08 2.000000e+08 5.000000e+08 2.000000e+08
1.000000e+09 3.000000e+09 2.000000e+08 3.000000e+08 2.000000e+08 2.000000e+08
1.000000e+09 3.000000e+09 2.000000e+08 3.000000e+08 3.000000e+08 2.000000e+08
1.000000e+09 3.000000e+09 2.000000e+08 3.000000e+08 4.000000e+08 2.000000e+08
1.000000e+09 3.000000e+09 2.000000e+08 3.000000e+08 5.000000e+08 2.000000e+08
1.000000e+09 3.000000e+09 2.000000e+08 4.000000e+08 2.000000e+08 2.000000e+08
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1.000000e+09 3.000000e+09 2.000000e+08 4.000000e+08 4.000000e+08 2.000000e+08
1.000000e+09 3.000000e+09 2.000000e+08 4.000000e+08 5.000000e+08 2.000000e+08
1.000000e+09 3.000000e+09 2.000000e+08 5.000000e+08 2.000000e+08 2.000000e+08
1.000000e+09 3.000000e+09 2.000000e+08 5.000000e+08 3.000000e+08 2.000000e+08
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1.000000e+09 3.000000e+09 2.000000e+08 5.000000e+08 5.000000e+08 2.000000e+08
```
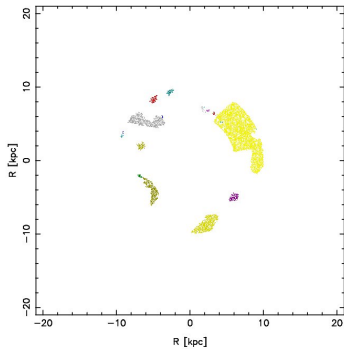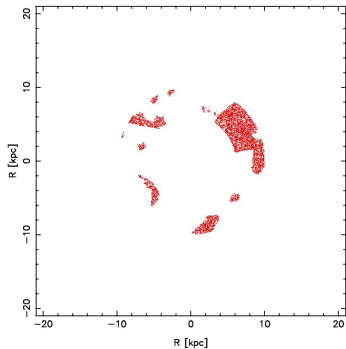
Neki rezultati
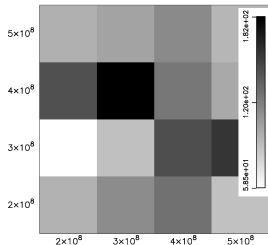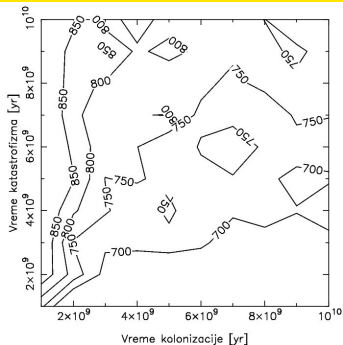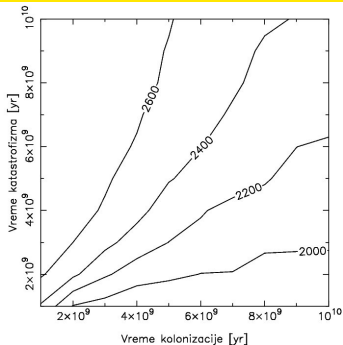
Poboljšanja:
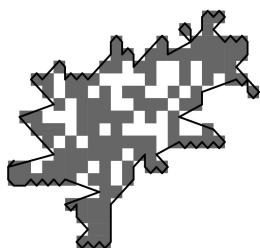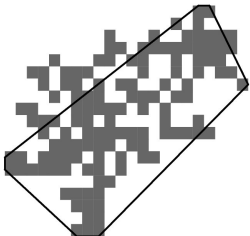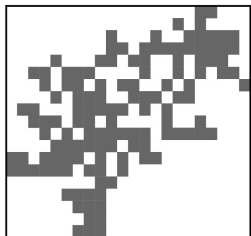
simplex
+
nenormalne
raspodele
verovatnoće

Perkolacija

Mapiranje klastera

,,Pakovanje" klastera

Kvantifikacija

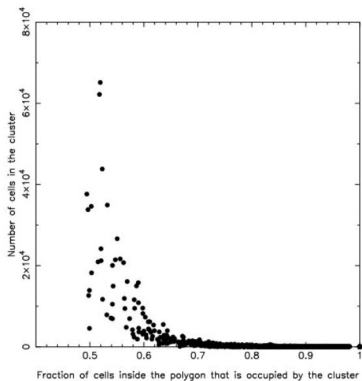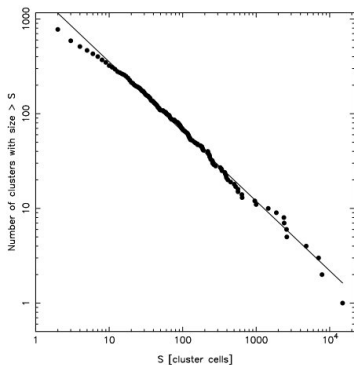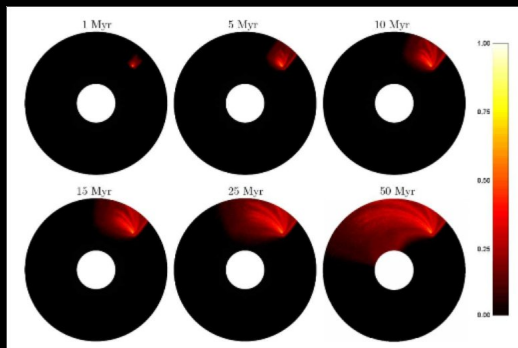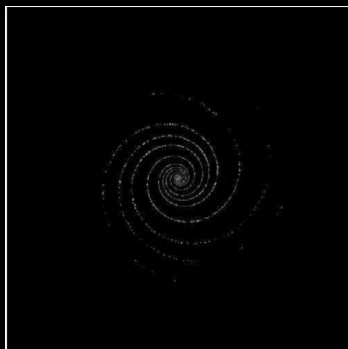Vukotic B., Cirkovic, M.M., 2012, OLEB, 42, 347-371.

Figure 7. Mass index $\alpha = 1.72 \pm 0.01$ of the same set of clusters as in Fig. 6.

$$N(> S) \propto S^{-\alpha}$$

Još neki modeli

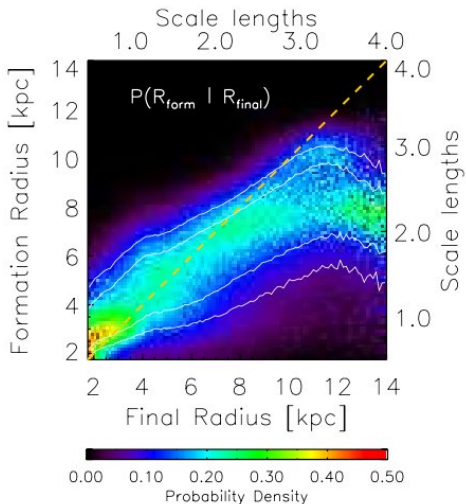Left: Forgan, D., 2009, IJAsB, 8, 121.
Right: Cotta, C., Morales, A., 2009, JBIS, 62, 82.

I još: Govanlock, M.G., Patton, D.R. and McConnell, S.M., 2011, Astrobiology, 11(9), 855.
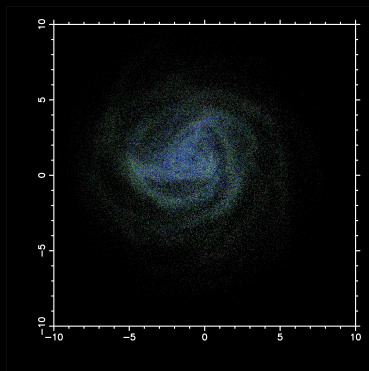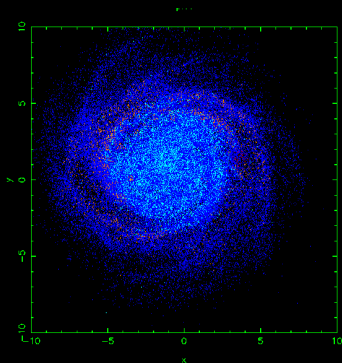
Mešanje populacija

Roškar, R., et al., 2011, ASPC, 448, 371.

"Preliminarni" rezultati

Martinez Aviles, G., Steinhauser, D., Vukotić, B., Ćirković, M.M., Schindler, S., 2013, in prep.

Mapiranje arhipelaga...

HVALA NA PAŽNJI!!!