

# SimpleMC

Estimación de parámetros de modelos de energía oscura y otras curiosidades

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- 1 Introducción
- 2 Estructura
- 3 Ejemplos
- 4 Cómo contribuir

# Motivación

## SimpleMC: toolbox for cosmological data analysis

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<https://github.com/ja-vazquez/SimpleMC>

# Análisis de datos

- Estimación del Máximo Likelihood (MLE):

$$\ln \mathcal{L}(D, \theta) = \sum_{i=1}^n \ln f(x_i; \theta),$$

$$\theta_{MLE} = \arg \max(\mathcal{L}(D, \theta, ))$$

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- Estimación del A Posteriori (MAP)  $P(\theta, D)$  ó estimación de parámetros ó inferencia Bayesiana. Por Teorema de Bayes:

$$P(\theta, D) = \frac{\mathcal{L}(D, \theta)P(\theta)}{P(D)}$$

y luego:

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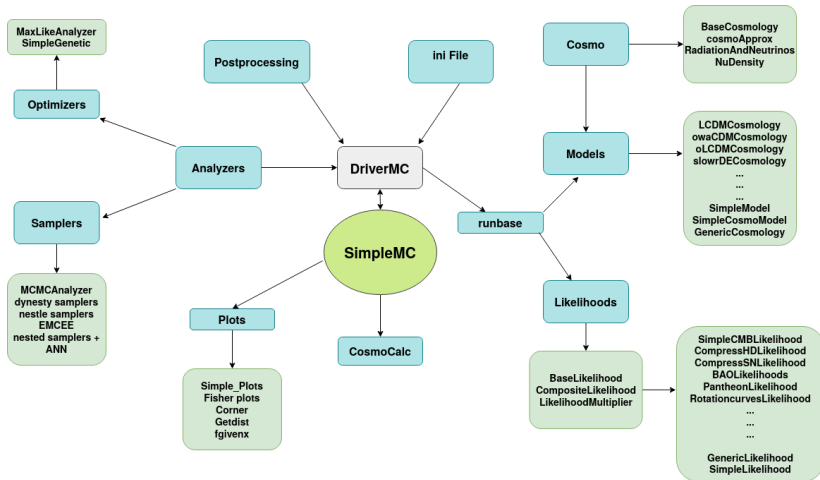
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- Visualización.
- Interpretación física.

# Estructura



# Modelos

Modelo	Ecuación de Friedmann ( $H^2/H_0^2$ )
$\Lambda$ CDM	$\Omega_{cb}a^{-3} + \Omega_{\Lambda} + \rho_{\nu+r}(z)/\rho_{\text{crit}}$
$o\Lambda$ CDM	$\Omega_{cb}a^{-3} + \Omega_{\Lambda} + \rho_{\nu+r}(z)/\rho_{\text{crit}} + \Omega_k a^{-2}$
$w$ CDM	$\Omega_{cb}a^{-3} + \Omega_{\text{de}}a^{-3(1+w)} + \rho_{\nu+r}(z)/\rho_{\text{crit}}$
$ow$ CDM	$\Omega_{cb}a^{-3} + \Omega_{\text{de}}a^{-3(1+w)} + \rho_{\nu+r}(z)/\rho_{\text{crit}} + \Omega_k a^{-2}$
$w_0 w_a$ CDM	$\Omega_{cb}a^{-3} + \Omega_{\text{de}}a^{-3(1+w_0+w_a)} \exp[-3w_a(1-a)] + \rho_{\nu+r}(z)/\rho_{\text{crit}}$

# Modelos

Modelo	Ecuación de Friedmann ( $H^2/H_0^2$ )
Slow Roll Dark Energy	$\Omega_{cb}a^{-3} + \rho_{\nu+r}(z)/\rho_{\text{crit}} + \Omega_{DE} \left[ a^{-3}/(\Omega_m a^{-3} + \Omega_{DE}) \right]^{\delta w_0/\Omega_{DE}}$
$ow_0w_a$ CDM	$\Omega_{cb}a^{-3} + \Omega_{de}a^{-3(1+w_0+w_a)} \exp[-3w_a(1-a)] + \rho_{\nu+r}(z)/\rho_{\text{crit}} + \Omega_k a^{-2}$
PolyCDM	$\Omega_{cb}a^{-3} + (\Omega_1 + \Omega_k)a^{-2} + \Omega_2 a^{-1} + (1 - \Omega_{cb} - \Omega_k - \Omega_1 - \Omega_2)$
Early Dark Energy	See relevant section.
Decaying Dark Matter	See relevant section.
$\nu$ CDM	free neutrino mass ( $\Sigma m_\nu < 1 \text{ eV}$ )
$\Delta N_{\text{eff}} \Lambda$ CDM	non-standard radiation component ( $2 < N_{\text{eff}} < 5$ )

# Datos

- SNIa
- Cronómetros cósmicos.
- BAO.
- Planck 2015 y 2018.- Versiones comprimidas de Planck-15 y Planck-18 (tratadas como un BAO a  $z = 1090$  )
- $f\sigma_8$

# Analizadores

- Optimizadores.
- Algoritmo de inferencia Bayesiana.

# Optimizadores

- MaxLikeAnalyzer.
- Algoritmo genético simple.



# Inferencia Bayesiana

- Metropolis-Hastings .
- Muestreo anidado.
- Emcee.

# Extras

- Métodos no paramétricos.
- MCEvidence.
- Redes neuronales.

# Salidas y gráficas

SimpleMC arroja como salida un `.paramnames`, un resumen y, para inferencia Bayesiana, un formato compatible con CosmoMC que se puede graficar con:

- `Simple_Plots` (nativo) .
- `corner`.
- `getdist`.
- `fgivenx`.

# Otros

- CosmoCalc
- Archivo ini para configuración del usuario.
- MPI y multiprocessing

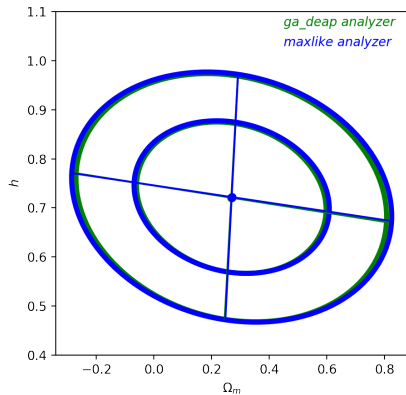
# MLE

maxlike	ga_deap
[custom]	[custom]
model = waCDM	model = waCDM
datasets = SN+HD	datasets = SN+HD
analyzer = maxlike	analyzer = ga_deap
	population = 200

## MLE

	maxlike	ga_deap
$\Omega_m$	0,2697	0,2683
$\Omega_b h^2$	0,0220	0,02201
$h$	0,7221	0,7207
$w_0$	-1,3668	-1,3564
$w_a$	1,3103	1,3206
$\max \log \mathcal{L}$	7,1334	7,1336

# MLE

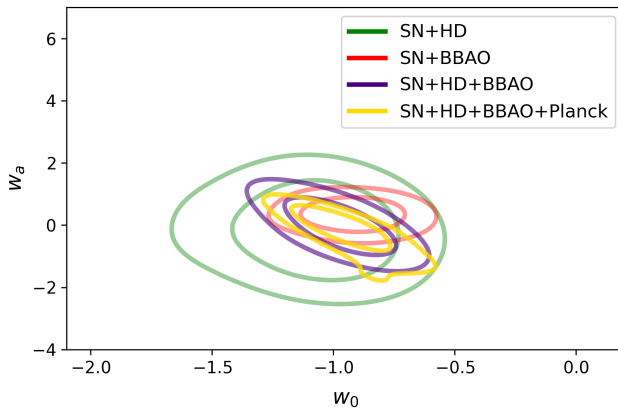


# MAP

```
[custom]
model = waCDM
datasets = SN+HD
analyzer = mcmc
mcevidence = False
[mcmc]
GRstop = 0.01
nsamp = 10000
```



## MAP



## MAP

	SN+HD	SN+BBAO	SN+HD	SN+BBAO+HD
$\Omega_m$	$0,3050 \pm 0,0775$	$0,2399 \pm 0,0472$	$0,2993 \pm 0,0180$	$0,3058 \pm 0,0103$
$\Omega_b h^2$	$0,0220 \pm 0,0005$	$0,0220 \pm 0,0004$	$0,0221 \pm 0,0005$	$0,0224 \pm 0,0003$
$h$	$0,6850 \pm 0,0324$	$0,5865 \pm 0,0673$	$0,6651 \pm 0,0206$	$0,6769 \pm 0,0111$
$w_0$	$-1,0202 \pm 0,1624$	$-0,8932 \pm 0,0934$	$-0,9420 \pm 0,0978$	$-0,9592 \pm 0,0966$
$w_a$	$-0,1983 \pm 0,9194$	$0,4076 \pm 0,3272$	$-0,1199 \pm 0,4291$	$-0,0765 \pm 0,3715$
$\max \log \mathcal{L}$	27,6746	23,5360	31,7931	30,7215

# Comparación de modelos

```
[custom]  
model = LCDM  
datasets = SN+HD  
analyzer = nested  
mcevidence = False
```

# Comparación de modelos

```
[custom]  
model = LCDM  
datasets = SN+HD  
analyzer = mcmc  
mcevidence = True
```

# Comparación de modelos

Método	ΛCDM (Modelo 1)	CPL (Modelo 2)
muestreo anidado	$-28,9465 \pm 0,1899$	$-30,8858 \pm 0,2246$
mcmc+mcevidence	-35,8112	-35,8611

# Comparación de modelos

Calculando el factor de Bayes:

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$$\begin{aligned} B_{12[nested]} &= -28,947 \pm 0,19 - (-30,886 \pm 0,225) \\ &= 1,939 \pm 0,035 \implies \textbf{Ventaja significativa para el modelo 1} \end{aligned}$$

# Comparación de modelos

Calculando el factor de Bayes:

$$\begin{aligned} B_{12[nested]} &= -28,947 \pm 0,19 - (-30,886 \pm 0,225) \\ &= 1,939 \pm 0,035 \implies \textbf{Ventaja significativa para el modelo 1} \end{aligned}$$

$$\begin{aligned} B_{12[mcevidence]} &= -35,811 - (-35,861) \\ &= 0,05 \implies \textbf{Ventaja poco convincente para el modelo 1} \end{aligned}$$

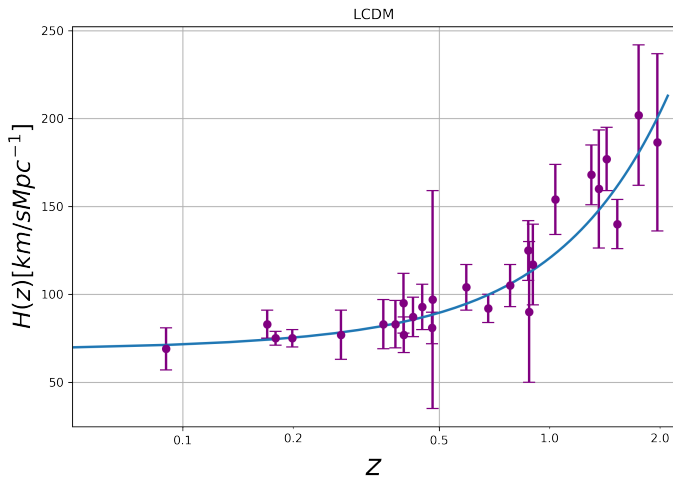


# CosmoCalc

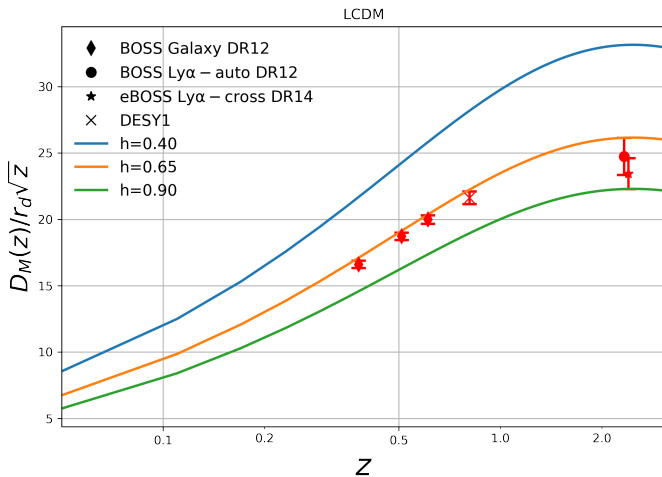
```
from simplemc.CosmoCalc import CosmoCalc

C_1 = CosmoCalc('LCDM', 'Hubble', plot_data=True, zmax=2.1)
C_2 = CosmoCalc('LCDM', 'DaOverrd', 'h', 0.4, 0.9, plot_data=True)
C_3 = CosmoCalc('LCDM', 'SNIa', plot_data=True, zmax=2.3)
C_4 = CosmoCalc('owaCDM', 'fs8', 'wa', -0.5, 0.5, 5, zmax=3.1, plot_data=True)
```

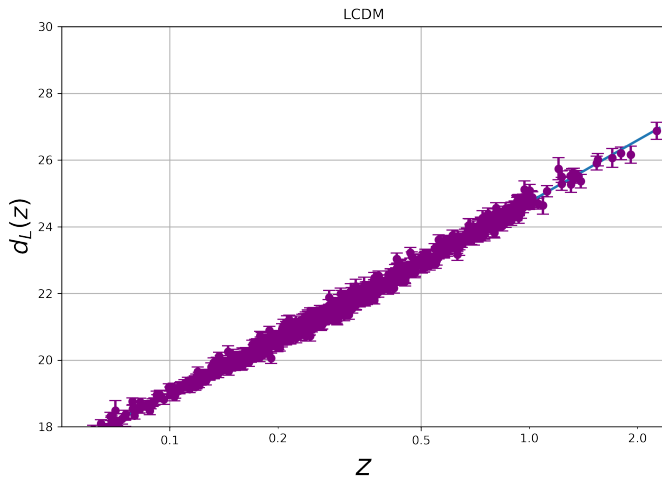
## CosmoCalc C1



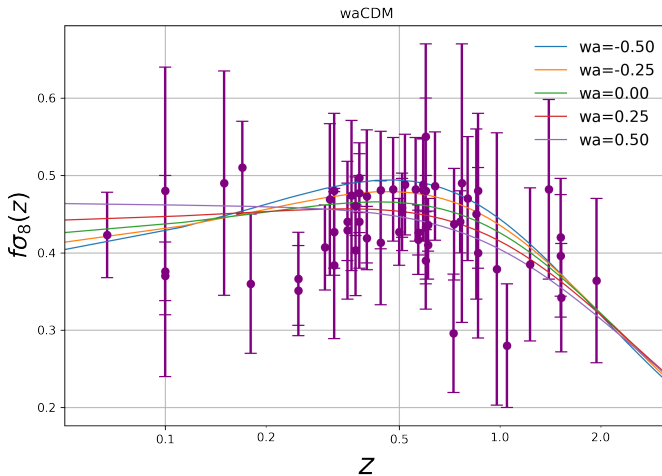
## CosmoCalc C2



## CosmoCalc C3



## CosmoCalc C4



# 1. Fork al repositorio original

The screenshot shows the GitHub repository page for `ja-vazquez / SimpleMC`. The repository is public. In the top right corner, the 'Fork' button is highlighted with a red box, showing 4 forks. Below the repository name, there are tabs for Code, Issues, Pull requests (1), Actions, Projects, Wiki, Security, and Insights. The main content area shows a list of files and their commit history. The right sidebar contains sections for About, Releases, and Packages.

ja-vazquez / SimpleMC Public

Unwatch 3 Unstar 11 Fork 4

<> Code Issues Pull requests 1 Actions Projects Wiki Security Insights

master 3 branches 0 tags

Go to file Add file Code

**About**  
Updated version of a simple MCMC code for cosmological parameter estimation where only expansion history matters.  
Readme  
GPL-2.0 License

**Releases**  
No releases published

**Packages**  
No packages published

File	Commit	Time
simplemc	update __init__	23 days ago
.gitignore	add *.pyc in gitignore	6 months ago
LICENSE	duplicate the fork repository	2 years ago
MANIFEST.in	update setup	24 days ago
README.md	update readme and setup	21 days ago
README_original.md	update readmes	2 years ago
baseConfig.ini	fix plot_param in [maxlike]	3 months ago
neuralTest.py	test neural	14 months ago
paraltest.py	working with mpirun -np 2 python3 paraltest.py	2 years ago

## 2. Clone a la copia

The screenshot shows the GitHub interface for the repository **igomezv / SimpleMC**, which is public and forked from **ja-vazquez/SimpleMC**. The repository has 4 branches and 0 tags. The main branch is **master**. A message indicates that this branch is 1 commit ahead of **ja-vazquez:master**.

The repository's commit history is shown below the message:

Commit	Author	Message
	igomezv	update readme
	simplemc	update __init__
	.gitignore	add *.pyc in gitignore
	LICENSE	duplicate the fork repository

The repository was updated 2 years ago.

The **Clone** dropdown menu is open, showing the following options:

- Clone** (with a question mark icon)
- HTTPS** SSH GitHub CLI
- URL: `https://github.com/igomezv/SimpleMC.git` (with a copy icon)
- Use Git or checkout with SVN using the web URL.
- Download ZIP** (with a download icon)

At the bottom, a terminal window shows the command to clone the repository:

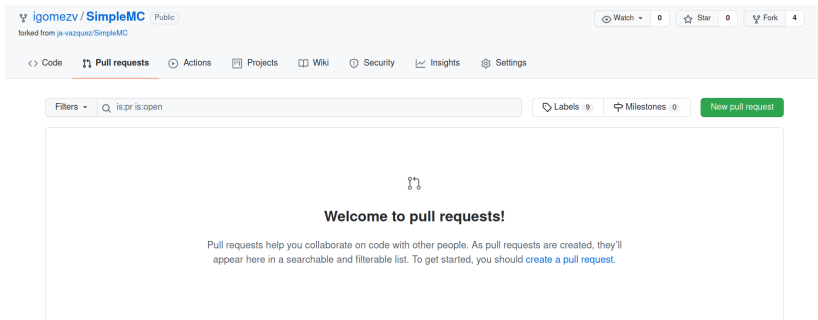
```
lsidro@ubik:~/Documents/github$ git clone https://github.com/igomezv/SimpleMC.git
```

### 3. Commit y push a los cambios realizados en la copia

```
(base) isidro@ubik:~/Documents/gitHub/SimpleMC$ git commit -m "add X parameterization in a new DE model" simplemc/runbase.py simplemc/models/new_model.py baseConfig.ini
```



## 4. Pull request al repo original



## 4. Pull request al repo original

The screenshot shows the GitHub interface for the repository `ja-vazquez / SimpleMC`, which is public. The top navigation bar includes links for Code, Issues, Pull requests (1), Actions, Projects, Wiki, Security, and Insights. On the right, there are buttons for Unwatch (3), Unstar (11), and Fork (4).

Below the navigation bar, the 'Pull requests' tab is selected, showing a search filter `is:pr is:open` and a 'New pull request' button. The list of pull requests shows one open request titled `update readme`, opened 9 days ago by `igomezv`. The table headers for the pull requests list are: Author, Label, Projects, Milestones, Reviews, Assignee, and Sort.

	Author	Label	Projects	Milestones	Reviews	Assignee	Sort
1 Open ✓ 17 Closed							
<code>update readme</code> #22 opened 9 days ago by <code>igomezv</code>							

# Bonus

Explorar documentación si da tiempo.

<https://igomezv.github.io/SimpleMC/>



**Gracias.**