

# Universality of halos shape as a strong cosmological probe

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Action Dark Energy

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# Halo Collapse

*CDM*: **concordance** model with 6 parameters and  $w = -1$ . Other dynamical **realistic** DE models (**quintessence**  $w > -1$ , **phantom**  $w < -1$  ...) exist that are compatible with CMB/SNIa. We will use here the  $2 \times 10^{12}$  -  $10^{14} M_{\odot}$  halos of  $\Lambda$ CDM.

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*? b .. C H b q . C z < b s \ b v b L % S ^ < b Y K e s C ?*

**Not at all** : Power Spectrum

$P(k) \propto h^2(k) \delta^2$  is cosmological dependent [Alimi et al. 2010]

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How to compare?

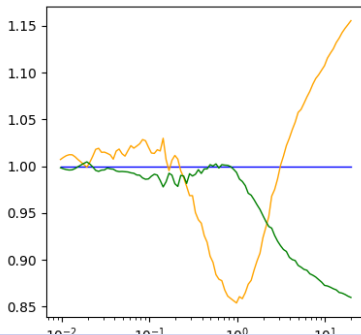
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on the right,  $\frac{P}{P_{\Lambda\text{CDM}}} = \frac{P_{\text{CDM}}}{P_{\Lambda\text{CDM}}}$

Behaviors and critical  $k_C$  depend on the cosmology.



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Where are we in terms of mass ?



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RMS of Linear fluctuations

$$\begin{aligned} \sigma^2 &= \frac{4}{3} \frac{M}{R^3} \int_0^R k^2 P^{lin}(k) W^2(kR) dk \\ &= \frac{1}{2} \int_{R_+} \dots \end{aligned}$$

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The "pure" non linear RMS relative to the  $\Lambda$ CDM one:

$$\frac{\tilde{\sigma}(M)}{\sigma_{\Lambda\text{CDM}}(M)} = \frac{\sigma(M)}{\sigma_{\Lambda\text{CDM}}(M)}$$

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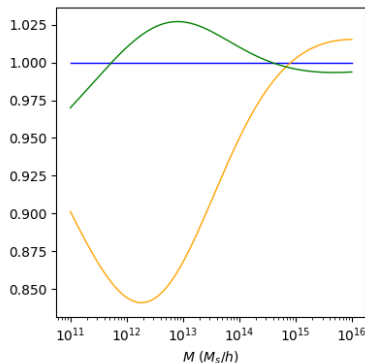
$$\begin{aligned} \sigma^2(M) &= \frac{4}{3} R^3 \int_{R_+}^{\infty} k^2 P^{lin}(k) W^2(kR) dk \\ &= \frac{1}{2} \int_{R_+}^{\infty} k^2 P^{lin}(k) W^2(kR) dk \end{aligned}$$

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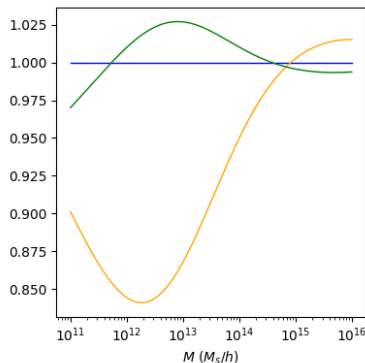
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$\ll 10^{15} M_S$

# Considerations on the halo shape

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Halos are essentially **triaxial**. [Doroshkevich 1973; Sheth, Mo, and Tormen 2001; Rossi 2012; Jing and Suto 2002; Bailin and Steinmetz 2005; Kasun and Evrard 2005; Allgood 2005; Allgood et al. 2006; Vera-Ciro et al. 2011; Limousin et al. 2013]

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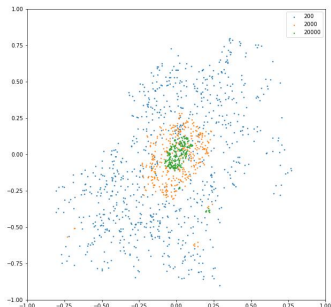
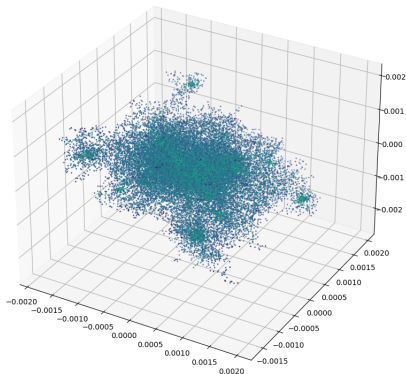


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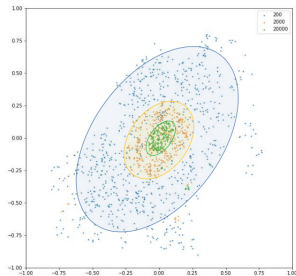
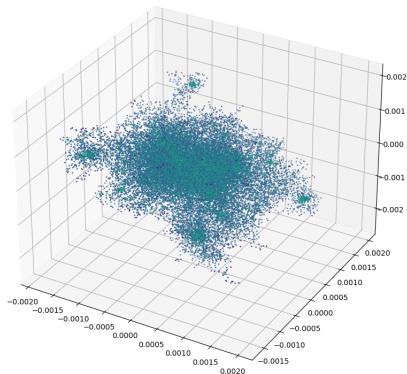
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S`2pBQmbHv Ua6k kykRV

HKQB/2MiB+ H bT iB H /E  
i?2 ? HQb

S`2pBQmbHv Ua6k kykRV

HKQB/2MiB+ H bT iB H /E  
i?2 ? #@b

S`2pBQmbHvUa6k kykRV

HKQB/2MiB+ H bT iB H /E  
i?2 ? #Qb  
mbBMpb M/ Ui`B tB HV  
T`Q}H2bii`B#mi2b

S`2pBQmbHv Ua6k kykRV

HKQB/2MiB+ H bT iB H /E  
i?2 ? #Qb  
mbBMpb M/ Ui`B tB HV  
T`Q}H2bii`B#mi2b  
`2KQpBM;Tm`BQH2p2`  
> MbV 2z2+ib

S`2pBQmbHv Ua6k kykRV

HKQB/2MiB+ H bT iB H /E  
i?2 ? #Qb

mbBMbb M/ Ui`B tB HV  
T`Q}H2bii`B#mi2b

`2KQpBM;Tm`BQH2p2`  
> MbV 2z2+ib

:` /B2Mi #QQbiBM; i`22b +  
\*.J M/ \_S\*.J ? HQb Udy W



S`2pBQmbHv Ua6k kykRV

HKQB/2MiB+ H bT iB H /E  
i?2 ? #Qb  
mbBMbb M/ Ui`B tB HV  
T`Q}H2bii`B#mi2b  
`2KQpBM;Tm`BQH2p2`  
> MbV 2z2+ib  
:` /B2Mi #QQbiBM; i`22b +  
\*.J M/\_S\*.J ? HQb Udy W  
Aiöb rQ`FBM;X

S`2pBQmbHv Ua6k kykRV

HKQB/2MiB+ H bT iB H /E  
i?2 ? #Qb  
mbBMbb M/ Ui`B tB HV  
T`Q}H2bii`B#mi2b  
`2KQpBM;Tm`BQH2p2`  
> MbV 2z2+ib  
:` /B2Mi #QQbiBM; i`22b +  
\*.J M/ \_S\*.J ? HQb Udy W  
Aiöb rQ`FrBiM;X

J FBM; i? 2 / B z 2 ` 2 M + 2

6 Q ` i ? 2 H Q + a H 2 0 0 2 B H H B T b Q B / H b ? 2 H H - r 2 + Q K T m i 2  
i 2 M b Q ` V b 2 K B @ ; u ; b X H 2 M ; i ? b

J FBM; i? 2 / B z 2` 2 M + 2

6 Q` i? 2 H Q + a H 2 0 B` 2 H H B T b Q B / H b? 2 H H - r 2 + Q K T m i 2  
i 2 M b Q` V b 2 K B @; t; B X J H M M B i M b B + i Q` b ,

$$E = \frac{a \cdot c}{2(a+b+c)} - p = \frac{a \cdot 2b+c}{2(a+b+c)}$$

h` B t B U H B i v VT =  $\frac{a^2}{a^2} - \frac{b^2}{c^2}$  U y 4 T M + F 2 ff R 4 } H

J FBM; i? 2 / B z 2` 2 M + 2

6 Q` i? 2 H Q + a H 2 0 B` 2 B H H B T b Q B / H b ? 2 H H - r 2 + Q K T m i 2  
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6 Q` i? 2 H Q + a H 2 0 B` 2 B H H B T b Q B / H b? 2 H H - r 2 + Q K T m i 2  
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h` B t B U H B i v VT =  $\frac{a^2 - b^2}{a^2 + b^2}$  U y 4 T M + F 2 f f R 4 } H

h @ J 2 / B b M i i 2` T H Q i ,

b H` 2 / v M Q i B + 2 / # v Q H B - M /  
M / (" Q M K B ; Q 2 i H X k y R 8 ) 2 H H B T i B  
T` Q H i T 2 M b` 2 H i B Q M / 2 T  
i? 2 7 Q` K i B Q M ? B b i Q z W Q  
M / r 2 // i? i B i H b Q / 2 T 2  
U ; 2 M 2` H H v V Q M + Q b K Q H

# J FBM; i? 2 / B z 2` 2 M + 2

6 Q` i? 2 H Q + a H 2 0 B` 2 B H H B T b Q B / H b? 2 H H - r 2 + Q K T m i 2  
i 2 M b Q` V b 2 K B @; h; B X J H M 2 M B i M b B + i Q` b ,

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h @ J 2 / B b M i i 2` T H Q i ,

b H` 2 / v M Q i B + 2 / # v Q H B - M /  
kyR9) M / (" Q M K B ; Q 2 i H X kyR8) 2 H H B T i B  
T` Q H i T 2 M b` 2 H i B Q M / 2 T  
i? 2 7 Q` K i B Q M ? B b i Q z W Q  
M / r 2 // i? i B i H b Q / 2 T 2  
U ; 2 M 2` H H v V Q M + Q b K Q H  
h Q m M / 2` b i M / i? B b + Q b K  
/ 2 T 2 M / 2 M + 2 - i? 2 # 2 b i r v  
B i - B 2 i Q } M / + Q b K Q H Q ;  
7 m M + i B Q M X i f c ( M ) B b  
+ Q b K Q H Q ; B + H H v B M / 2 T 2

hQr ` / mMBp2`b HBiv UAV



hQr ` / mMBp2`b HBiv UAV

6QH HQrBM: H2imb  
B Mi` Q/m HB M? Xb /2MbBiv }2H/ ,

hQr ` / mMBp2`b HBiv UAV

6QH HQrBM: H2i mb  
B Mi` Q/m HB M? X b / 2 Mb Biv } 2H/ ,

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r? 2`2 q Bb : mbbB M rBM/Qr 7mM+iBQM  
M/ i? 2 T2 F (? 2a) BB 0+ c= X

hQr ` / mMBp2`b HBiv UAV

6QH HQrBM; H2imb  
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r? 2`2 q Bb : mbbB M rBM/Qr 7mM+iBQM

M/ i? 2 T2 F ? 2 BB 0 = X

h? 2 + ` BiB+ H B2M bB2`v b HQrH` B bBM; Hv- i? 2 + m` p2  
p `vBM; 7mM+iBQM Q7 (;T) bT + 2 i? (M; B) MbT + 2X

# hQr ` / IMBp2`b HBiv UAAV

"mi r2 + M ;Q Km+? 7m`i?2`, H2i mb  
Bmi`Q/m+2 i?2 MQM@HBM2 ``Kb UmbBM; i?2  
LG TQr2` bT2+i`mKV ,

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M/ i?2 + Q `` 2bTQM/BMXT2 F ?2B;?i

hQr ` / IMBp2`b HBiv UAAV

"mi r2 + M ;Q Km+? 7m`i?2`, H2i mb  
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A(MT) bT +2- i?2 +m`p2b bmT2`TQb2  
HKQbi +QKTH2i2Hv ,

hQr ` / IMBp2`b HBiv UAAV

"mi r2 + M ;Q Km+? 7m`i?2`, H2i mb  
B Mi`Q/m+2 i?2 MQM@HBM2 ``Kb UmbBM; i?2  
LG TQr2` bT2+i`mKV ,

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M/ i?2 + Q``2bTQM/BMXT2 F ?2B;?i  
A(MT) bT +2- i?2 + m`p2b bmT2`TQb2  
HKQbi + QKTmQiiB2W,fbJiQ  
+m`p28 iB K2b HQR2`  
h?Bb`2bmHi ?QH/b MQi QMHv 7Q` i?2  
K2/B M +m`p2b Ur2 THQ`i ?2`2V #mi  
i?2 r?QH2 TQ7Bi?i2 B #u2B+2Ti  
i?2 KQbi 2ti`2K2 p Hm2bVX

hQr ` / IMBp2`b HBiv UAAV

"mi r2 + M ;Q Km+? 7m`i?2`, H2i mb  
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LG TQr2` bT2+i`mKV ,

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M/ i?2 + Q` ` 2bTQM/BMXT2 F ?2B;?i  
A(MT) bT +2- i?2 +m`p2b bmT2`TQb2  
HKQbi +QKTmQiiB2M,fbJiQ

+m`p28`iB K2b HQr2`

h?Bb`2bmHi?QH/bMQi QMMV7Q2`i?Q`/b-r2? p2 b1

K2/B M +m`p2b Ur2 T HQ`i?2`?2V+#ObKQHQ;B+ H +QM

i?2 r?QH2 TQ7Bi?2 B#U2B+2M b? T2 Bb 2K#2//2/ BM i?2

i?2 KQbi 2ti`2K2 p Hm2bVX TQr2` bT2+i`mK

:2iiBM; HH iQ;2i?2`

LQr r2 ? p2 BM ? M/ HH i?2 iQQHb iQ #mBH/ #` M/  
MQM@HBM2 `TQr2` bT2+i`mK,



:2iiBM; HH iQ;2i?2`

LQr r2 ? p2 BM ? M/ HH i?2 iQQHb iQ #mBH/ #` M/  
MQM@HBM2 `TQR2` bT2+i`mK,  
J2 b mi`?M;T) +m`p2 BM Qm` mMBp2`b2X

:2iiBM; HH iQ;2i?2`

LQr r2 ? p2 BM ? M/ HH i?2 iQQHb iQ #mBH/ #` M/  
MQM@HBM2 `TQR2` bT2+i`mK,

J2 b mi`2Q(M;T) +m`p2 BM Qm` mMBp2`b2X

aBM+2 r2 FMQBp(2;T) H2H iBQM- QM2 + -(M)/2/m+2

7mM+iBQM Q7 Qm` IMBp2`b2X

:2iiBM; HH iQ;2i?2`

LQr r2 ? p2 BM ? M/ HH i?2 iQQHb iQ #mBH/ #` M/  
MQM@HBM2 `TQr2` bT2+i`mK,

J2 b mi`2(M;T) +m`p2 BM Qm` mMBp2`b2X

aBM+2 r2 FMQM B p(2;T) H2H iBQM- QM2 + -(M)/m+2

7mM+iBQM Q7 Qm` IMBp2`b2X

P(k) Bb }M HHv /B`2+iHv(N)M72``2/7`QK

AM i2`Kb Q7 +QbKQHQ;B+ H T `K2i2`b- b? T2 m #`mpi

?B;?Hv /2T2M/ QM Ui? X M Q M T H B M 2 +`QKT m i (H B B Q M ) b kyk

\_2bmHib 7Q` Qi?2` ;2QK2i`B+ H [m

q? i #Qmi k. \

\* Q M + H m b B Q M M / T 2 ` b T 2 + i B p 2 b

6 ` Q K ? M H Q # v T Q H C M i Q 7 p B 2 r - K b b b ? T 2 T ` Q } H  
A - + M / 2 i 2 + i + Q b K Q H Q ; B + H b B ; M i m ` 2

\* Q M + H m b B Q M M / T 2 ` b T 2 + i B p 2 b

6 ` Q K ? M H Q # v T Q H B M i Q 7 p B 2 r - K b b b ? T 2 T ` Q } H  
A - + M / 2 i 2 + i + Q b K Q H Q @ B T + Q H p B 2 M i ? m i ` 2 2 m M / 2 ` b  
M / p Q B / M v b T m ` B Q m b 2 z 2 + i - # K m + ? B T M ; v i b ? E + r H  
F M Q r H X / ; 2

A i r Q ` F b # 2 + m b 2 - i B ` Q T B Q B M i Q 7 p B 2 r - ? H Q b b ?  
+ Q b K Q H Q ; B + H B M 7 Q ` K i B Q M ,

\* Q M + H m b B Q M M / T 2 ` b T 2 + i B p 2 b

6 ` Q K ? M H Q # v T ? Q H Q M i Q 7 p B 2 r - K b b b ? T 2 T ` Q } H  
A - + M / 2 i 2 + i + Q b K Q H Q @ B T + Q h p B B 2 M i ? m i ` 2 2 m M / 2 ` b  
M / p Q B / M v b T m ` B Q m b 2 z 2 + i - # K m + ? B T M ; v i b ? E + r H  
F M Q r H X / ; 2

A i r Q ` F b # 2 + m b 2 - i B ` Q T B Q B M i Q 7 p B 2 r - ? H Q b b ?  
+ Q b K Q H Q ; B + H B M 2 Q ` 2 M B B Q ? M H Q b b M Q Q i H S a M 2 `  
U r ? B + ? B b ? B ; ? H v + Q b K Q H Q ; B + H H v B K T ` 2 ; M i 2



IMBp2`b HBiv Q7 ? HQb b? T2 b  
T`Q#2

\_ûKv EQbF b  
.Q+iQ` H /pBbQ`, C2 M JB+?2H HBK

+iBQM . `F 1M2`;v

LQp2K#2` Rd- kykk

J + ? B M 2 G 2 ` M B M ;

J + ? B M 2 G 2 ` M B M ;

q ? 2 ` 2 / Q 2 b i ? 2 + Q b K Q H Q ; v H B 2 K Q M ; i ? 2 K Q ` T ? Q H Q ; B +  
i ? 2 ? H Q b \

J + ? B M 2 G 2 ` M B M ;

q ? 2 ` 2 / Q 2 b i ? 2 + Q b K Q H Q ; v H B 2 K Q M ; i ? 2 K Q ` T ? Q H Q ; B +  
i ? 2 ? H Q b r 2 F b B ; M # 2 / 2 i 2 + i 2 /

J + ? B M 2 G 2 ` M B M ;

q ? 2 ` 2 / Q 2 b i ? 2 + Q b K Q H Q ; v H B 2 K Q M ; i ? 2 K Q ` T ? Q H Q ; B +  
i ? 2 ? H Q b r 2 F b B ; M Q # 2 / 2 i 2 + i 2 /  
J + ? B M 2 ` M B M ; U F A V + Q m H / / Q b Q

J + ? B M 2 G 2 ` M B M ;

q ? 2 ` 2 / Q 2 b i ? 2 + Q b K Q H Q ; v H B 2 K Q M ; i ? 2 K Q ` T ? Q H Q ; B +

i ? 2 ? H Q b r 2 F b B ; M Q # 2 / 2 i 2 + i 2 /

J + ? B M 2 ` M B M ; U F A V + Q m H / / Q b Q

H ` 2 / v m b 2 / B M + Q b K Q H Q ; v f b i ` Q T ? v b B + b

J +?BM2 G2 `MBM;

q?2`2 /Q2b i?2 +QbKQHq;v HB2 KQM; i?2 KQ`T?QHq;B+  
i?2 ? HQbr2 F bB;MQ #2 /2i2+i2/

J +?BM2 `MBM; U F AV +QmH/ /Q bQ

H`2 /v mb2/ BM +QbKQHq;vf bi`QT?vbB+b

L@#Q/BKmh iBQMb @ H2 `M iQ bbQ+B i2 iQ MBiB

/Bbi`B#(m+2@aBi? \$i2tiBi)&2i H' kyR3

# J +?BM2 G2 `MBM;

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H`2 /v mb2/ BM +QbKQHq;vf bi`QT?vbB+b

L@# Q/B Kmh iBQMb @ H2 `MiQ bbQ+B i2 iQ MBiB  
/Bbi`B#miBQM

\*QbKQHq;B+ H 2`QbKQHq;B i2` /Bbi`B#miBQM- 2  
/22T H2 `MBM; Q?2i?2 # +F;` QmM/+QbKQHq;vX



J +?BM2 G2 `MBM;

q?2`2 /Q2b i?2 +QbKQHq;v HB2 KQM; i?2 KQ`T?QHq;B+  
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H`2 /v mb2/ BM +QbKQHq;vf bi`QT?vbB+b

L@# Q/BKmh iBQM b @ H2 `MiQ bbQ+B i2 iQ MBiB

/Bbi`B#(miBQM \$i2tiBi)&2i H' kyR3

\*QbKQHq;B+ H 2`QbKQHq;BQ ii2` /Bbi`B#miBQM- 2

/22T H2 `MBM Q?2i?2 # +F;`QmM/ +QbKQHq;vX

q2 iQQF /Bz2`2Mi TT`Q +?

J +?BM2 G2 `MBM;

q?2`2 /Q2b i?2 +QbKQHq;v HB2 KQM; i?2 KQ`T?QHq;B+  
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J +?BM2 `MBM; U F AV +QmH/ /Q bQ

H`2 /v mb2/ BM +QbKQHq;vf bi`QT?vbB+b

L@#Q/BKmh iBQM b @ H2 `MiQ bbQ+B i2 iQ MBiB

/Bbi`B#(miBQM \$i2tiBi)&2i H'kyR3

\*QbKQHq;B+ H 2`QbKQHq;B+ Q ii2` /Bbi`B#miBQM- 2

/22T H2 `MBM Q?2i?2 # +F;`QmM/ +QbKQHq;vX

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L@#Q/BKmh iBQMb @ H2 `MiQ bbQ+B i2 iQ MBiB  
/Bbi`B#miBQM

\*QbKQHq;B+ H2`QbKQHq;B+ QbKQHq;B+ H2`QbKQHq;B+  
/22T H2 `MBM Q?2i?2 # +F;`QmM/+QbKQHq;vX

q2 iQQF /Bz2`2Mi TT`Q +?

q2 ? p2 HQi Q7 ? HQb bBKmh i2/ BM /Bz2`2Mi +Q

J +?BM2 G2 `MBM;

q?2`2 /Q2b i?2 +QbKQHq;v HB2 KQM; i?2 KQ`T?QHq;B+  
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J +?BM2 `MBM; U F AV +QmH/ /Q bQ

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L@#Q/BKmh iBQM b @ H2 `MiQ bbQ+B i2 iQ MBiB

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\*QbKQHq;B+ H 2`QbKQHq;BQK ii2` /Bbi`B#miBQM- 2

/22T H2 `MBMq Q?2i?2 # +F;`QmM( pMQ ?k?QzitiQ &jiH' kyR

q2 iQQF /Bz2`2Mi TT`Q +?

q2 ? p2 HQi Q7 ? HQb bBKmh i2/ BM /Bz2`2Mi +QI

1 +? ? BbQ/2b+`B#2/[im`Qib; iBp2 TUQTQ}B2T `K2i

bQ QM?@bB+b T`BQ`b

J +?BM2 G2 `MBM;

q?2`2 /Q2b i?2 +QbKQHq;v HB2 KQM; i?2 KQ`T?QHq;B+  
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/22T H2 `MBMq Q?2i?2 # +F;`QmM/ +QbKQHq;vX'H'kyR

q2 iQQF /Bz2`2Mi TT`Q +?

q2 ? p2 HQi Q7 ? HQb bBKmh i2/ BM /Bz2`2Mi +Q

1 +? ? BbQ/2b+`B#2/[im`Qib;?iBp2 TUQTQ}B2T `K2i

bQ QM?@bB+b T`BQ`b

q2 +QM+2Bp2 JG 2M;BM2 iQ bbQ+B i2 iQ Mv T`Q

ii`B#mi2bö p Hm2bV i?2 # +F;`QmM/ +QbKQHq;v

U+H bbB}+ iBQMii?2Fp Hm2b Q7 +QbKQHq;B2b HBTVM

J +?BM2 G2 `MBM;

q?2`2 /Q2b i?2 +QbKQHq;v HB2 KQM; i?2 KQ`T?QHq;B+  
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\*QbKQHq;B+ H 2`bQK iBQK ii2` /Bbi`B#miBQM- 2

/22T H2 `MBM Q?2i?2 # +F;`QmM/ +QbKQHq;vX' H' kyR

q2 iQQF /Bz2`2Mi TT`Q +?

q2 ? p2 HQi Q7 ? HQb bBKmh i2/ BM /Bz2`2Mi +QF

1 +? ? BbQ/2b+`B#2/[im`Qib;?iBp2 TUQTQ}B2T `K2i

bQ QM?@bB+b T`BQ`b

q2 +QM+2Bp2 JG 2M;BM2 iQ bbQ+B i2 iQ Mv T`Q

ii`B#mi2bö p Hm2bV i?2 # +F;`QmM/ +QbKQHq;v

U+H bbB}+ iBQM ii?2 Fp Hm2b Q7 +QbKQHq;B2b HBTQM

q2 i`v iQ /2i2`KBM2 r?B+? T`QT2`iB2b `2 BKTQ`i M

@ i?Qb2 `2 i?2 ô+QbKQHq;B+ HHv B?BT`B;M T2?ôbB

QmiTmi

GQQFBM; 7Q` i?2 ?B//2M ?Q` b2

Ai Bb +`m+B HiQ ~~Q~~ M/2` Bb MHiBM; 2M; BM2 rQ` FbX

GQQFBM; 7Q` i?2 ?B//2M ?Q` b2

Ai Bb +`m+B HiQ Qm/22` BbrMH iBM; 2M; BM2` rB+ Fmb-X` -  
iQ +?2+F i? ii?2 +H bbB}+ iBQM ?B b B+? B2op-2B; QMH  
+QbKQHQ; B+ H +Hm2 M Q K B B; +mHQ2KQ 7 2?2 bBKmH iE  
bTm` BQ2mbi bX AM Qi?2` rQ`/b- i?2 2M; B2M B?Q mb2/Xr



GQQFBM; 7Q` i?2 ?B//2M ?Q` b2

Ai Bb + `m+B HiQ Qm/22` BbrMH iBM; 2M;BM2` rQ+ Fmb-X` -  
iQ +?2+F i? ii?2 +H bbB}+ iBQM ?B b B+? B2p-2B; QMH  
+QbKQHQ;B+ H +Hm2 M Q K B B; +mHQKQ 7 2?2 bBKmH iE  
bTm` BQ2mbi bX AM Qi?2` rQ` /b- i?2 2M; B2M B? Q mb2/Xr

\* H2p2` > Mb  
1MvHQT2/B ``Bi MMB+

# Looking for the hidden horse

It is crucial to understand **how** the resulting engine works. In particular, we have to check that the classification is achieved only by **physical** means, ignoring any cosmological clue coming from the **numerical** nature of the simulation and other **spurious** effects. In other words, the engine should work on a **real** Universe.

**Clever Hans** : Encyclopedia Britannica

"The 'Clever Hans' effect occurs when the learned model produces correct predictions based on the 'wrong' features. This effect [...] goes undetected by standard validation techniques has been frequently observed [...] where the training algorithm leverages spurious correlations in the data."

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~~Y" qz Qbs \ bVL%P-Y \ -ssCs S` zPC zq S' sCz -q \ -YsYC bHzPC s-\ C 4-sC~~  
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~~, ^@~~  
~~-YsC b^@ Qbs \ bVL%P- Yb \ -ssCs -q \ -YsYC bH- ^bzPCq 4- sC \ -ss~~

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 $\propto \frac{1}{1+z} \frac{1}{-3-w} (1+z)^{-3-w} \Big|_{z=0}^{\infty} = \frac{1}{-3-w} (1+z)^{-2-w} \Big|_{z=0}^{\infty}$   
 $= \frac{1}{-3-w} (1+z)^{-2-w} \Big|_{z=0}^{\infty} = \frac{1}{-3-w} (1+z)^{-2-w} \Big|_{z=0}^{\infty}$   
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About 74% for two models ( ;  $RP$ )

Resistant to "attacks"

Output probabilities are calibrated [so that each "prediction" is assorted with a meaningful uncertainty]

Almost no bias from total mass (in the studied range)