

# El model de gota líquida

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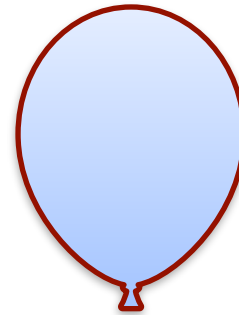
Institute of Cosmos Sciences

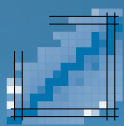
Universitat de Barcelona

&

Department of Physics

University of Surrey





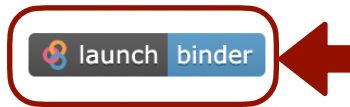
# Com córrer les activitats?

1. Navegueu aquí:

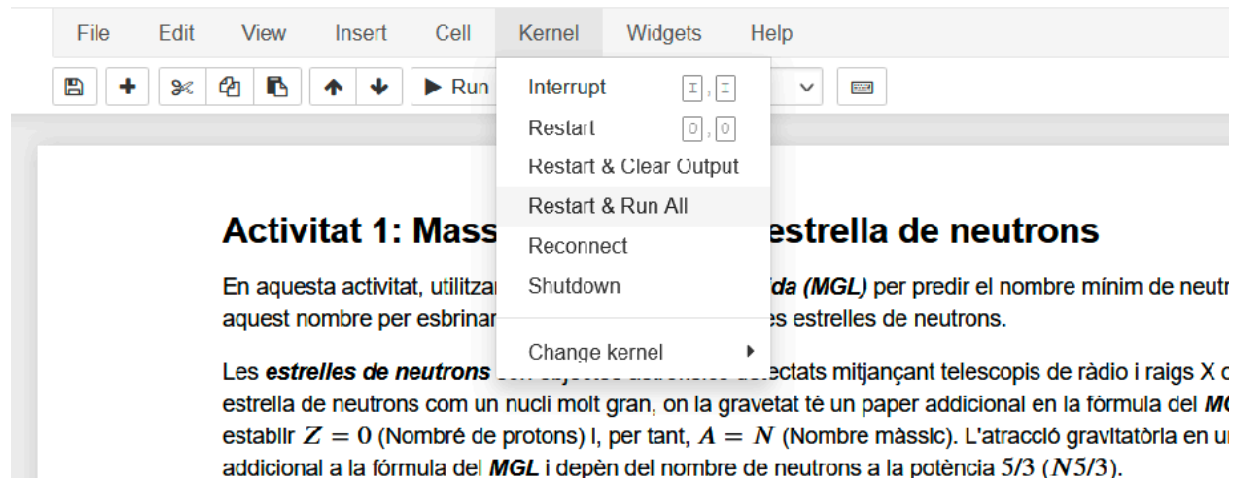
[https://github.com/arnauros/Divulgacio\\_Outreach/tree/main/Catala](https://github.com/arnauros/Divulgacio_Outreach/tree/main/Catala)

2. Busqueu la icona de **Binder**:

Enllaç al Binder de l'Activitat 1 - Model de Gota Líquida Troba els Paràmetres:

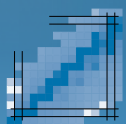


3. Espereu que **carregui** Binder. **Cliqueu** a Kernel > Restart & Run all



4. Seguiu les instruccions i **ompliu** el formulari final,

<https://forms.office.com/r/rDDD2RRTik>



# Isòtops

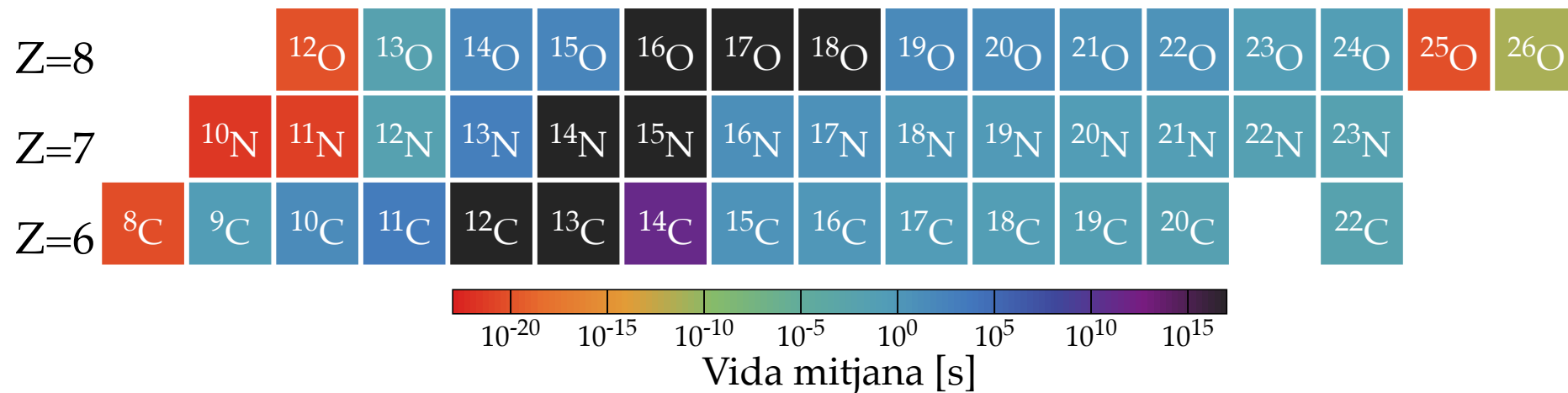
Nombre de massa  
 $A$

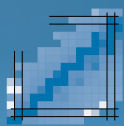
Isòtop

$14\text{O}$

Element  
Oxigen  $Z=8$

Neutrons  
 $N=A-Z=14-8=6$

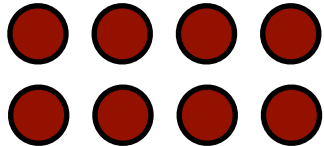




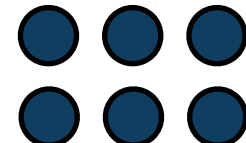
# Energia d'enllaç

## Oxigen 14 $^{14}\text{O}$

$Z=8$

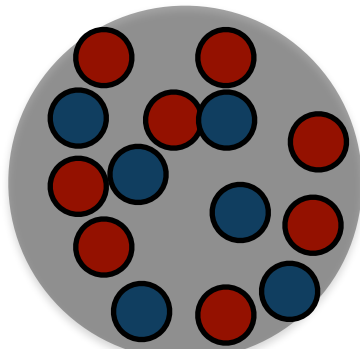


$N=14-8=6$



$$Mc^2 = 8m_p c^2 + 6m_n c^2 = 13144 \text{ MeV}$$

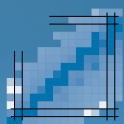
$^{14}\text{O}$



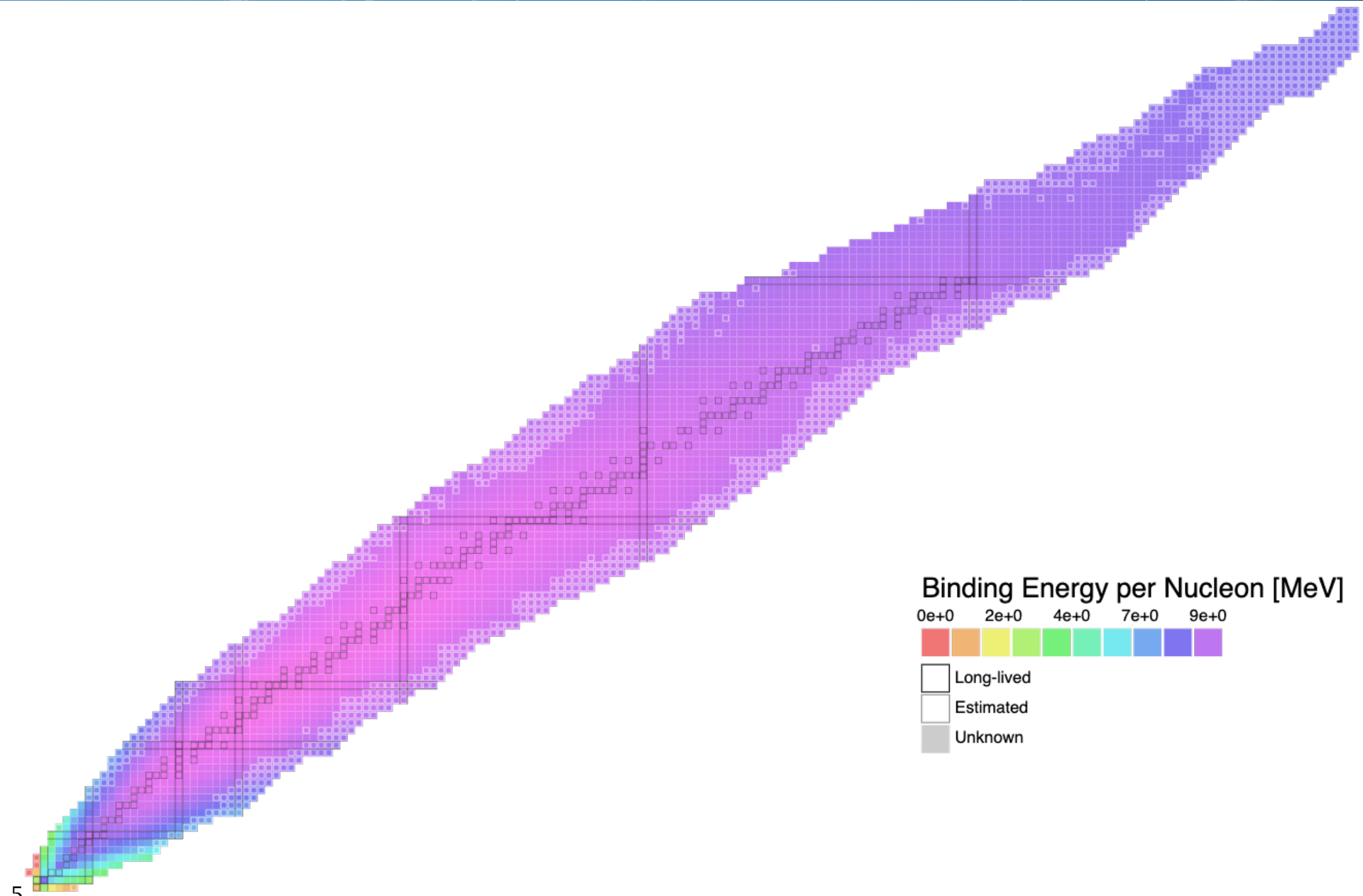
$$M_{14}c^2 = 13046 \text{ MeV}$$

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$$BE = 8m_p c^2 + 6m_n c^2 - M_{14}c^2 = 98 \text{ MeV}$$



# Energia d'enllaç



Binding Energy per Nucleon [MeV]

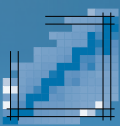
0e+0 2e+0 4e+0 7e+0 9e+0



Long-lived

Estimated

Unknown



# Formula de Bethe-Weizsäcker

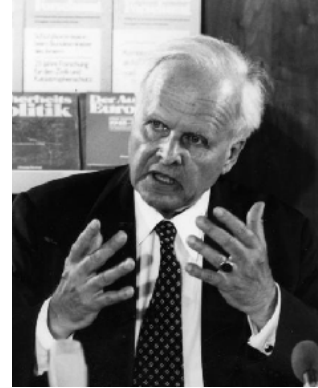
## Hans Bethe

(1906-2005) Nobel 1967



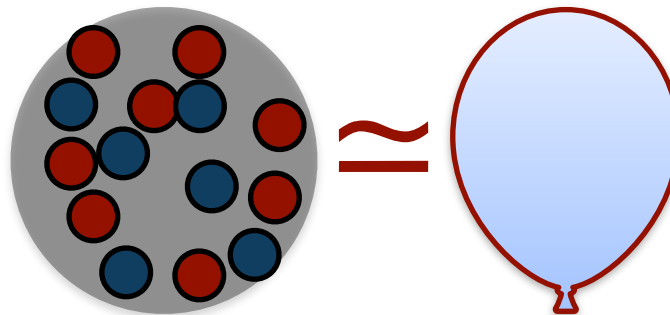
## C. F. von Weizsäcker

(1912-2007)



## Model de gota líquida

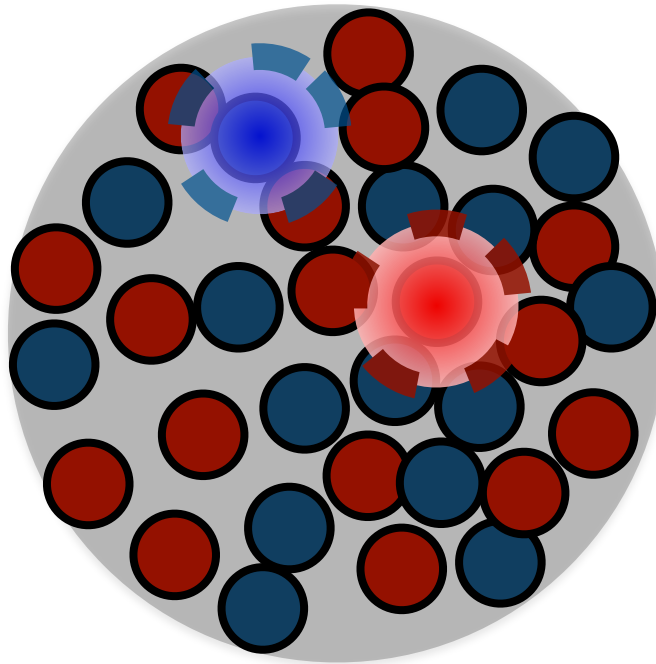
$$\frac{BE}{A} = a_V - \frac{a_S}{A^{1/3}} - a_C \frac{Z^2}{A^{4/3}} - a_A \frac{(N - Z)^2}{A^2} + a_P \frac{\delta_{N,Z}}{A}$$

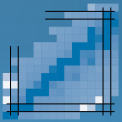


## Model de gota líquida

$$\frac{BE}{A} = a_V - \frac{a_S}{A^{1/3}} - a_C \frac{Z^2}{A^{4/3}} - a_A \frac{(N - Z)^2}{A^2} + a_P \frac{\delta_{N,Z}}{A}$$

## Volum



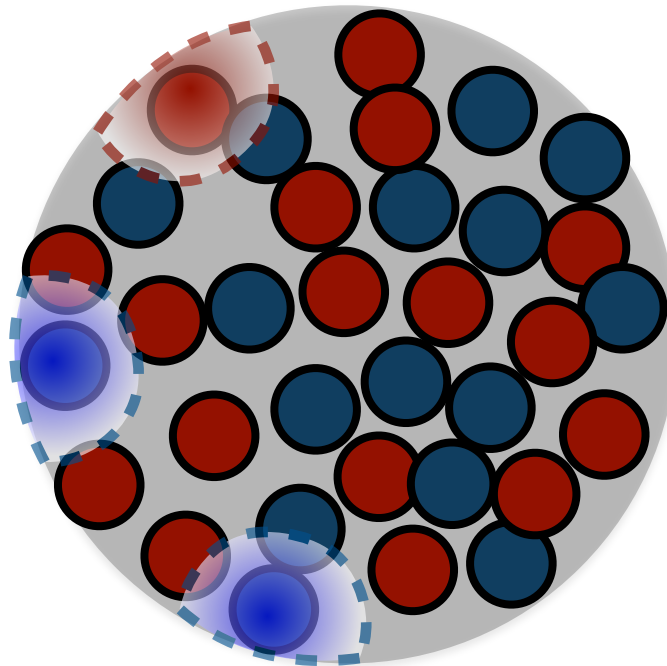


# Terme de volum

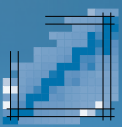
## Model de gota líquida

$$\frac{BE}{A} = a_V - \frac{a_S}{A^{1/3}} - a_C \frac{Z^2}{A^{4/3}} - a_A \frac{(N - Z)^2}{A^2} + a_P \frac{\delta_{N,Z}}{A}$$

## Superfície





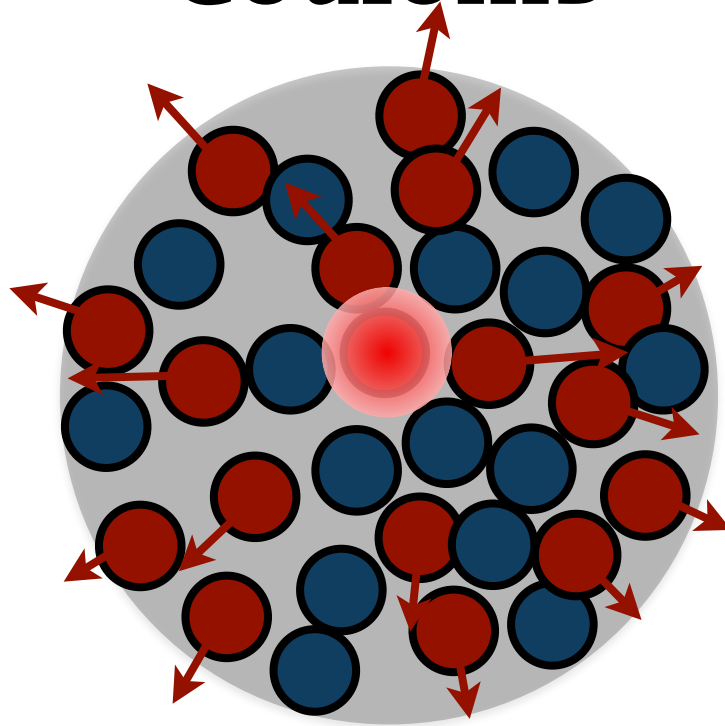


# Terme de volum

## Model de gota líquida

$$\frac{BE}{A} = a_V - \frac{a_S}{A^{1/3}} - a_C \frac{Z^2}{A^{4/3}} - a_A \frac{(N - Z)^2}{A^2} + a_P \frac{\delta_{N,Z}}{A}$$

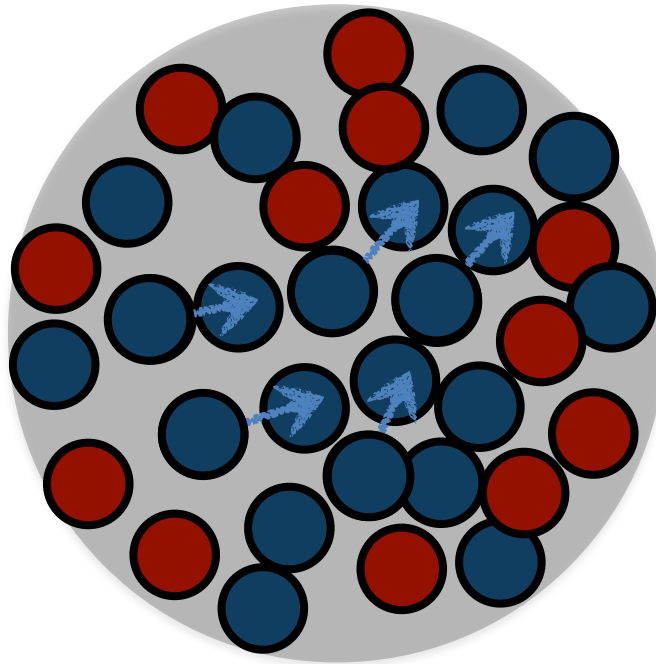
## Coulomb



## Model de gota líquida

$$\frac{BE}{A} = a_V - \frac{a_S}{A^{1/3}} - a_C \frac{Z^2}{A^{4/3}} - a_A \frac{(N - Z)^2}{A^2} + a_P \frac{\delta_{N,Z}}{A}$$

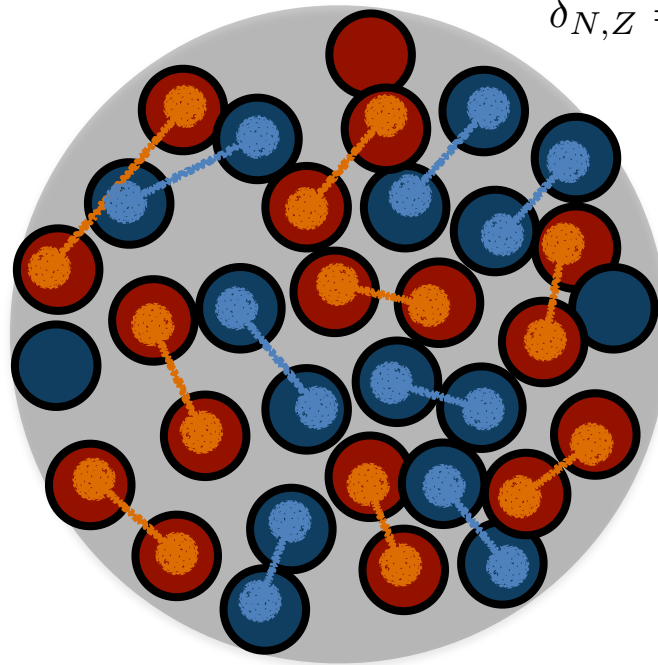
## Asimetria



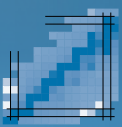
## Model de gota líquida

$$\frac{BE}{A} = a_V - \frac{a_S}{A^{1/3}} - a_C \frac{Z^2}{A^{4/3}} - a_A \frac{(N - Z)^2}{A^2} + a_P \frac{\delta_{N,Z}}{A}$$

## Aparellament



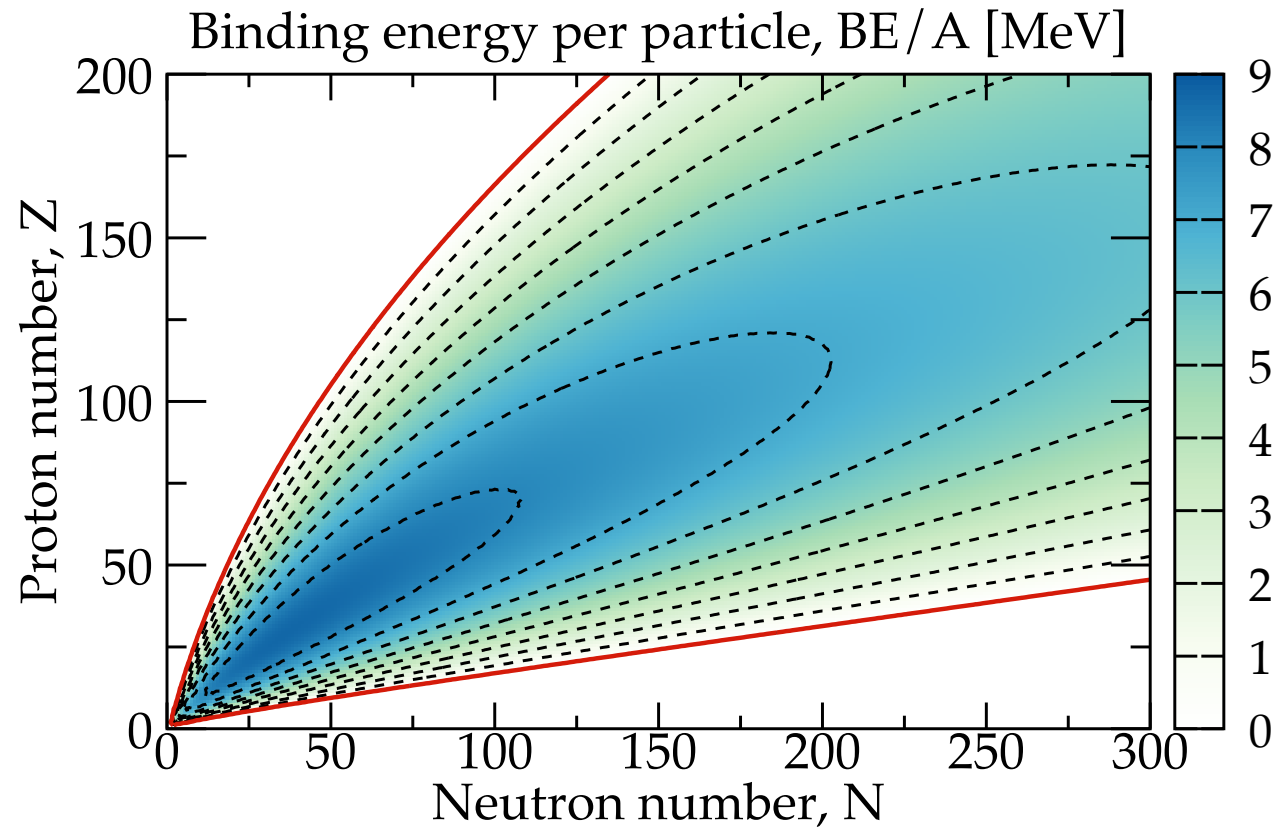
$$\delta_{N,Z} = \begin{cases} A^{-1/2}, & N \text{ parell i } Z \text{ parell,} \\ -A^{-1/2}, & N \text{ senar i } Z \text{ senar,} \\ 0, & \text{altre cas.} \end{cases}$$

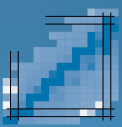


## Model de gota líquida

$$\frac{BE}{A} = a_V - \frac{a_S}{A^{1/3}} - a_C \frac{Z^2}{A^{4/3}} - a_A \frac{(N - Z)^2}{A^2} + a_P \frac{\delta_{N,Z}}{A}$$

	[MeV]
$a_V$	15,8
$a_S$	18,3
$a_C$	0,714
$a_A$	23,2
$a_P$	12,0





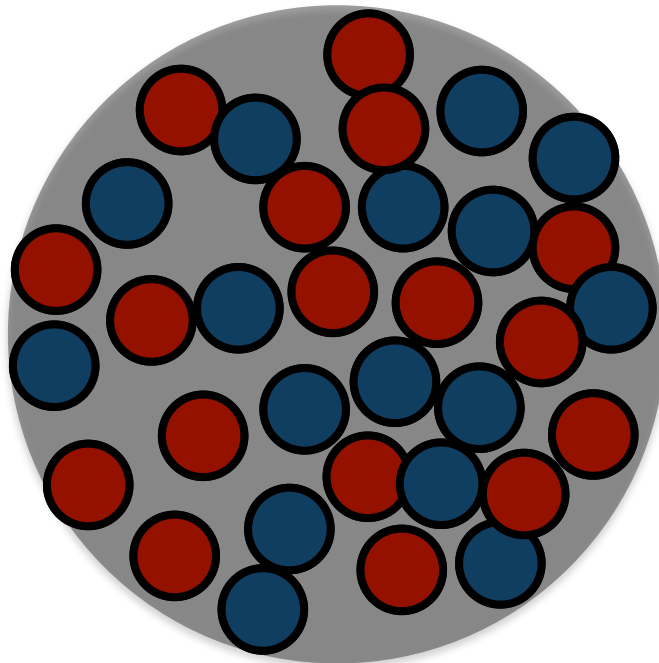
# Estrelas de neutrons

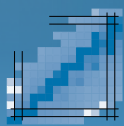
N neutrons:

$$\frac{BE}{A} = a_V - \frac{a_S}{A^{1/3}} - \frac{a_C}{A^{4/3}} - \frac{a_A}{A} + \frac{(N-Z)^2}{5N} \frac{M^2}{R^2} \frac{\delta_{N,Z}}{A}$$

$$\frac{BE}{N} = a_V - \frac{a_S}{N^{1/3}} - \frac{a_C}{N^{4/3}} - a_A \frac{(N-0)^2}{N^2} + a_P \frac{\delta_{N,Z}}{N}$$

$Z=0,$   
 $A=N$   
 $N \gg 1$





# Massa màxima?

## Compactesa

$$C = \frac{R_{\text{Sch}}}{R} = \frac{2GM}{Rc^2}$$

	Compactesa
Terra	$1 \times 10^{-9}$
Sol	$4 \times 10^{-6}$
Estrella neutrons	0.5
Forat negre	$> 1$

