Computazione e Fisica

ovvero:

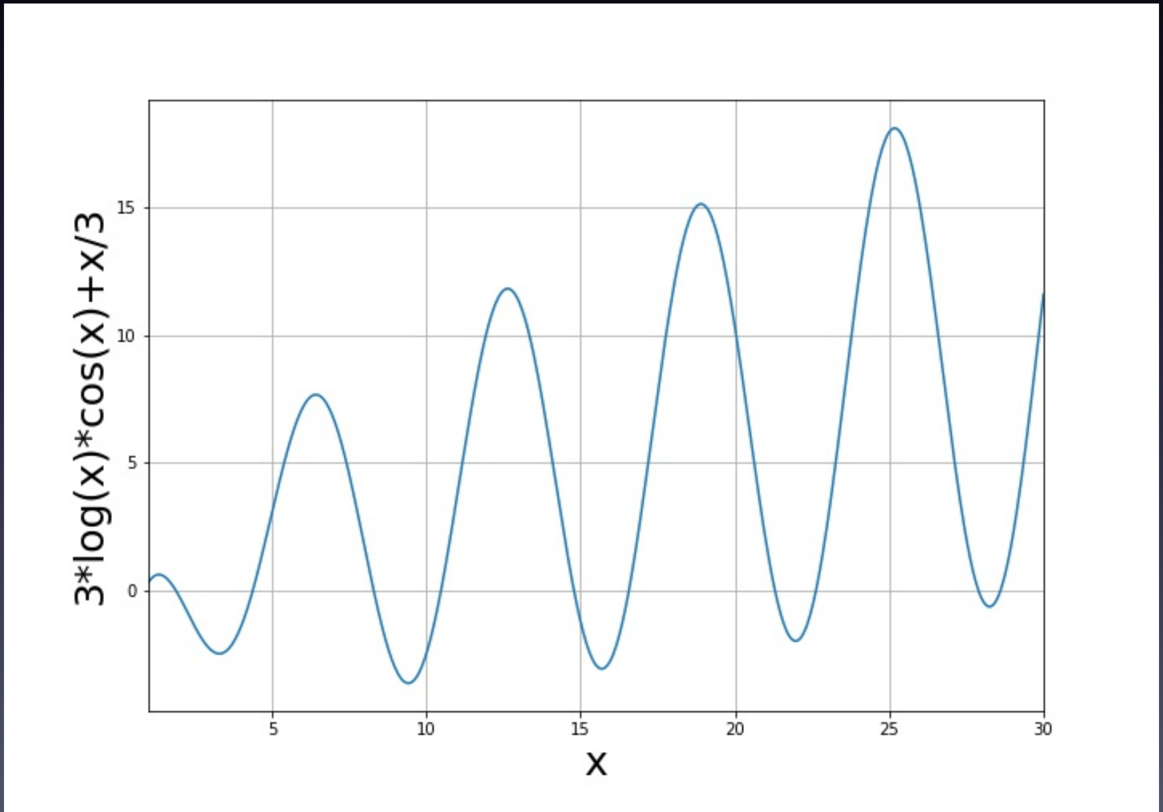
perchè Tecniche Informatiche

al primo semestre del primo anno?

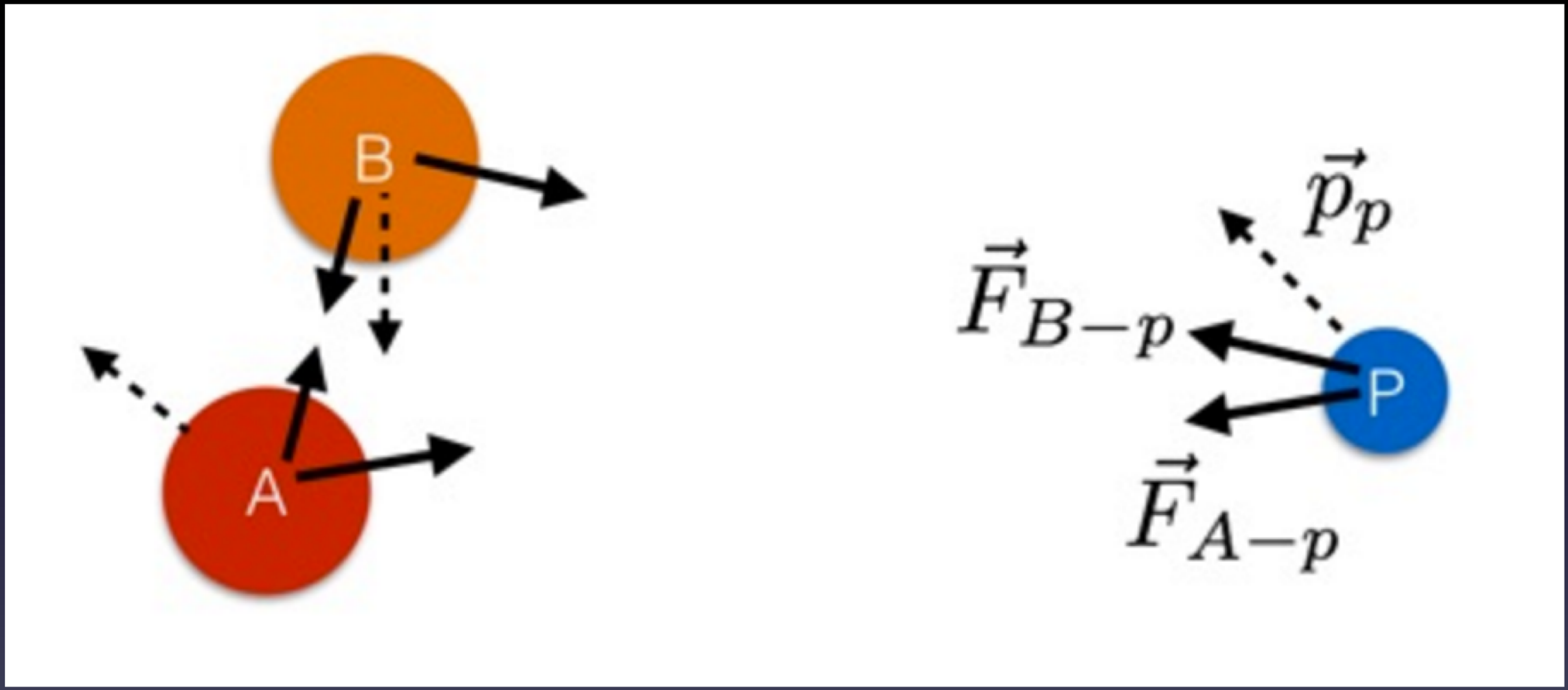
Problemi semplici non risolvibili analiticamente

$$a_n x^n + a_{n-1} x^{n-1} + \ldots + a_1 x + a_0 = 0$$

n > 4

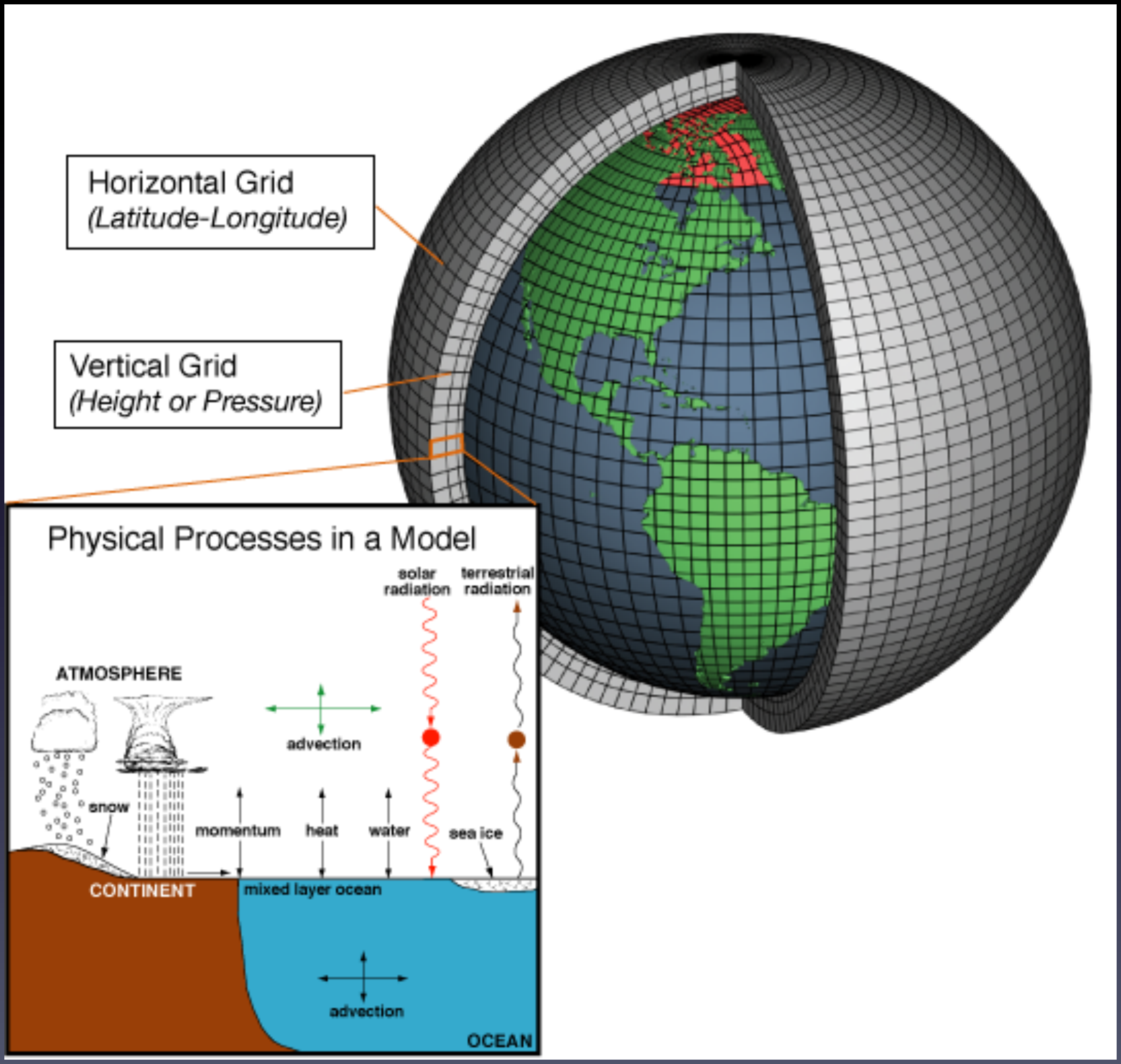


3 masse gravitanti: le forze sono note. Non sappiamo calcolare il moto.

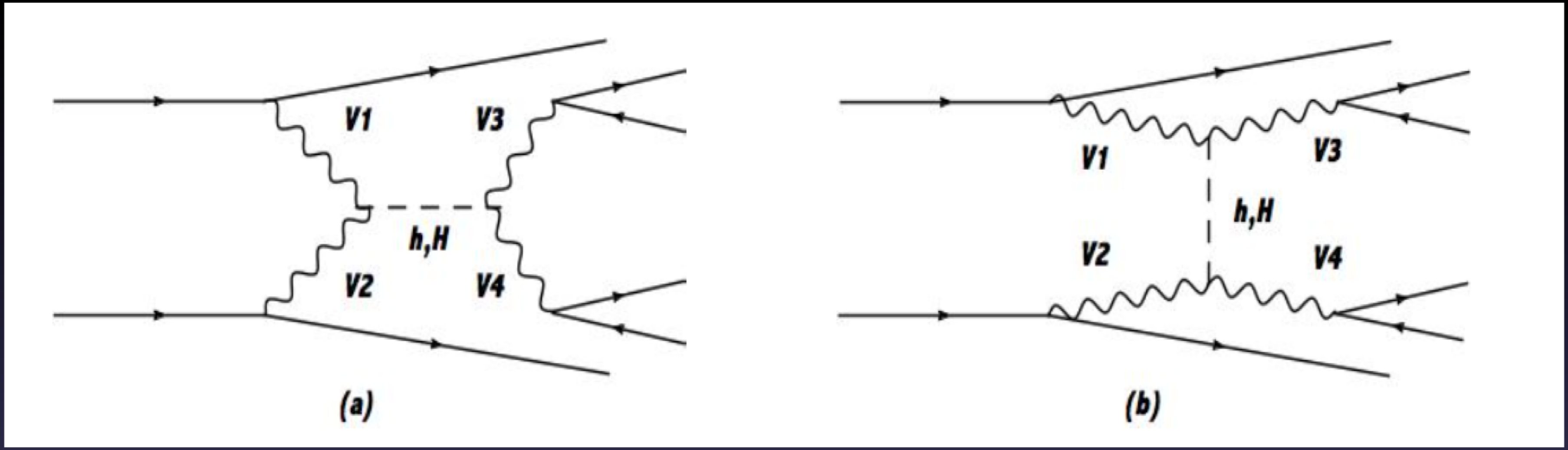


Problemi complessi

Dinamica dell'atmosfera



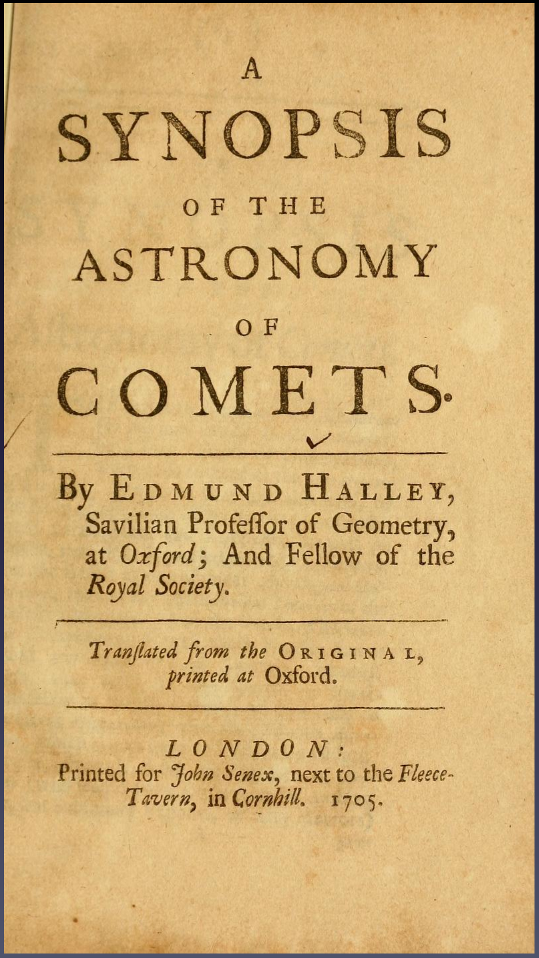
Urto fra particelle elementari   2 → n



Calcolare la distribuzione delle particelle finali :
- Centinaia di termini
- Integrazione su   3n-4   variabili

La necessità di eseguire calcoli complessi precede l’invenzione dei computer

Edmund Halley, 1705


A

SYNOPSIS

OF THE

ASTRONOMY

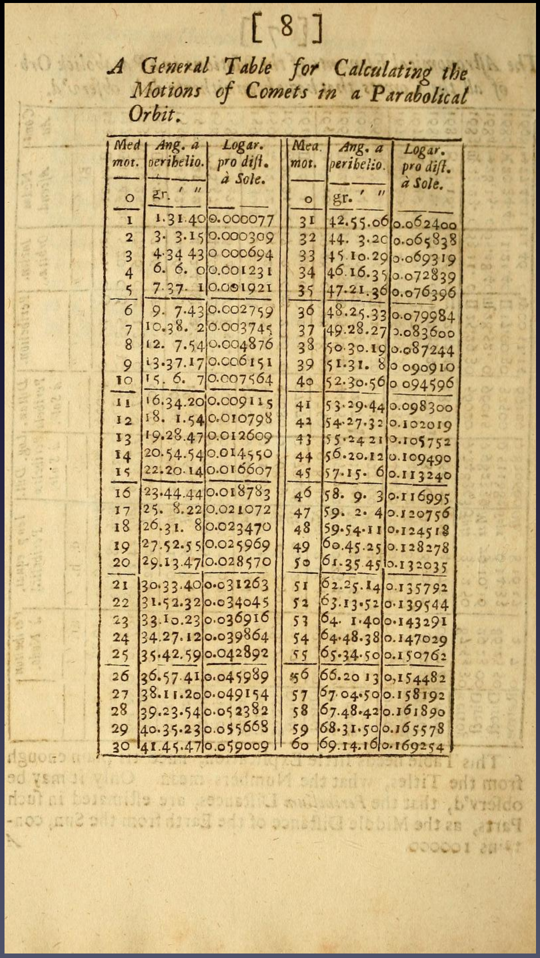
OF

COMETS.

By EDMUND HALLEY,
Savilian Professor of Geometry,
at *Oxford*; And Fellow of the
Royal Society.

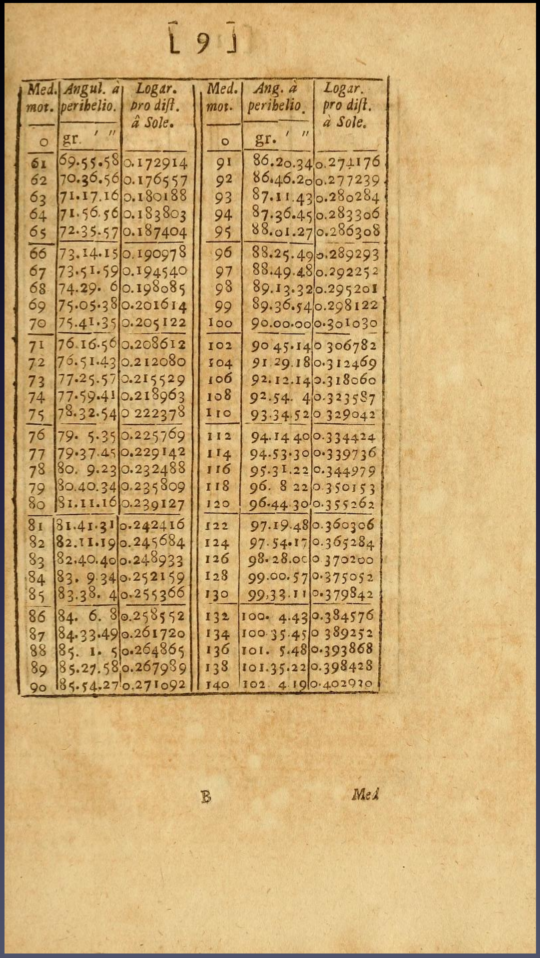
Translated from the ORIGINAL,
printed at Oxford.

LONDON:
Printed for *John Senex*, next to the *Fleece-Tavern*, in *Cornhill*. 1705.


[8]

A General Table for Calculating the Motions of Comets in a Parabolical Orbit.

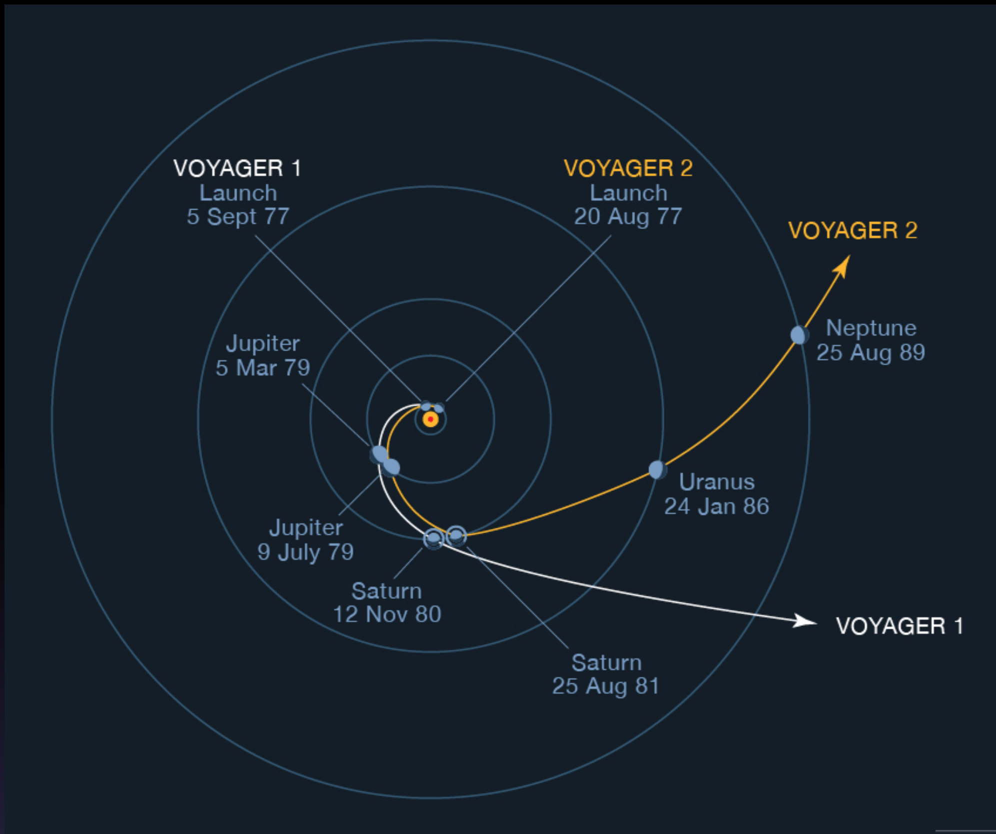
Med mot. o	Ang. a perihelio. gr. ' "	Logar. pro dist. à Sole.	Mea. mot. o	Ang. a perihelio. gr. ' "	Logar. pro dist. à Sole.
1	1.31.40	0.000077	31	42.55.06	0.062400
2	3. 3.15	0.000309	32	44. 3.20	0.065838
3	4.34 43	0 000694	33	45.10.29	0.069319
4	6. 6. 0	0.001231	34	46.16.35	0.072839
5	7.37. 1	0.001921	35	47.21.36	0.076396
6	9. 7.43	0.002759	36	48.25.33	0.079984
7	10.38. 2	0.003745	37	49.28.27	0.083600
8	12. 7.54	0.004876	38	50.30.19	0.087244
9	13.37.17	0.006151	39	51.31. 8	0 090910
10	15. 6. 7	0.007564	40	52.30.56	0 094596
11	16.34.20	0.009115	41	53.29.44	0.098300
12	18. 1.54	0.010798	42	54.27.32	0.102019
13	19.28.47	0.012609	43	55.24 21	0.105752
14	20.54.54	0.014550	44	56.20.12	0.109490
15	22.20.14	0.016607	45	57.15. 6	0.113240
16	23.44.44	0.018783	46	58. 9. 3	0.116995
17	25. 8.22	0.021072	47	59. 2. 4	0.120756
18	26.31. 8	0.023470	48	59.54.11	0.124518
19	27.52.55	0.025969	49	60.45.25	0.128278
20	29.13.47	0.028570	50	61.35 45	0.132035
21	30.33.40	0.031263	51	62.25.14	0.135792
22	31.52.32	0.034045	52	63.13.52	0.139544
23	33.10.23	0.036916	53	64. 1.40	0.143291
24	34.27.12	0.039864	54	64.48.38	0.147029
25	35.42.59	0.042892	55	65.34.50	0.150762
26	36.57.41	0.045989	56	66.20 13	0,154482
27	38.11.20	0.049154	57	67.04.50	0.158192
28	39.23.54	0.052382	58	67.48.42	0.161890
29	40.35.23	0.055668	59	68.31.50	0.165578
30	41.45.47	0.059009	60	69.14.16	0.169254


[9]

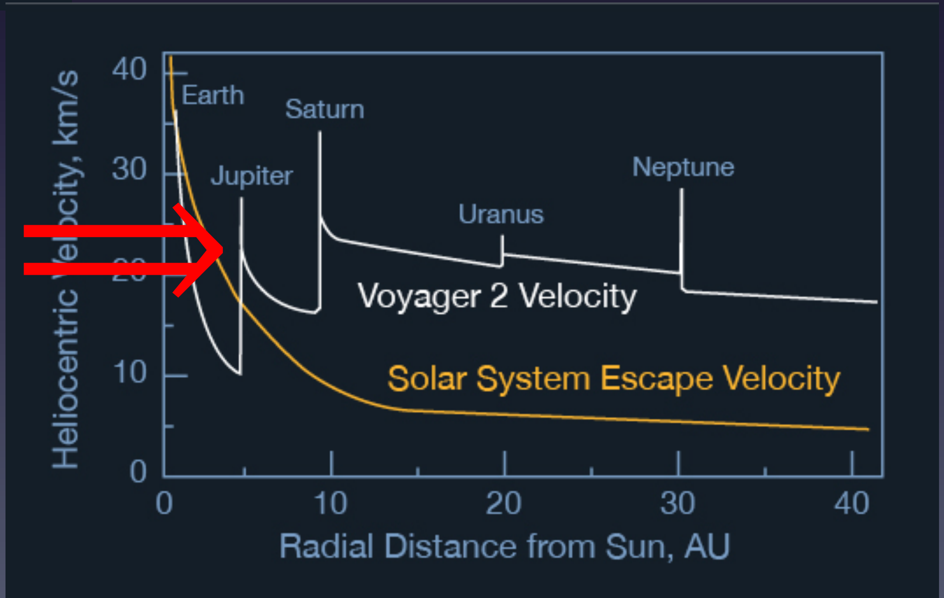
Med. mot. o	Angul. à perihelio. gr. ' "	Logar. pro dist. à Sole.	Med. mot. o	Ang. à perihelio. gr. ' "	Logar. pro dist. à Sole.
61	69.55.58	0.172914	91	86.20.34	0.274176
62	70.36.56	0.176557	92	86.46.20	0.277239
63	71.17.16	0.180188	93	87.11.43	0.280284
64	71.56.56	0.183803	94	87.36.45	0.283306
65	72.35.57	0.187404	95	88.01.27	0.286308
66	73.14.15	0.190978	96	88.25.49	0.289293
67	73.51.59	0.194540	97	88.49.48	0.292252
68	74.29. 6	0.198085	98	89.13.32	0.295201
69	75.05.38	0.201614	99	89.36.54	0.298122
70	75.41.35	0.205122	100	90.00.00	0.301030
71	76.16.56	0.208612	102	90 45.14	0 306782
72	76.51.43	0.212080	104	91 29.18	0.312469
73	77.25.57	0.215529	106	92.12.14	0.318060
74	77.59.41	0.218963	108	92.54. 4	0.323587
75	78.32.54	0 222378	110	93.34.52	0 329042
76	79. 5.35	0.225769	112	94.14 40	0.334424
77	79.37.45	0.229142	114	94.53.30	0.339736
78	80. 9.23	0.232488	116	95.31.22	0.344979
79	80.40.34	0.235809	118	96. 8 22	0.350153
80	81.11.16	0.239127	120	96.44.30	0.355262
81	81.41.31	0.242416	122	97.19.48	0.360306
82	82.11.19	0.245684	124	97.54.17	0.365284
83	82.40.40	0.248933	126	98.28.00	0 370200
84	83. 9.34	0.252159	128	99.00.57	0.375052
85	83.38. 4	0.255366	130	99.33.11	0.379842
86	84. 6. 8	0.258552	132	100. 4.43	0.384576
87	84.33.49	0.261720	134	100.35.45	0 389252
88	85. 1. 5	0.264865	136	101. 5.48	0.393868
89	85.27.58	0.267989	138	101.35.22	0.398428
90	85.54.27	0.271092	140	102. 4.19	0.402920

B Med

1924

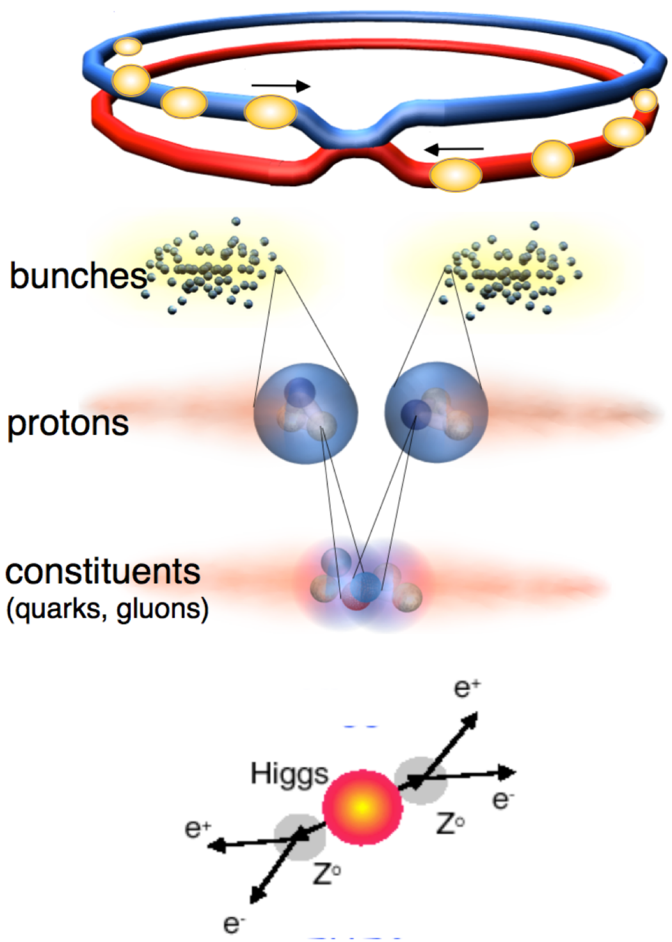


Effetto «fionda»



Un esperimento al CERN

proton collisions at LHC



- 2800 bunches of protons
- energy of each proton : 6.5 TeV
- 100 billions protons / bunch
- beam crossing rate: 40 MHz

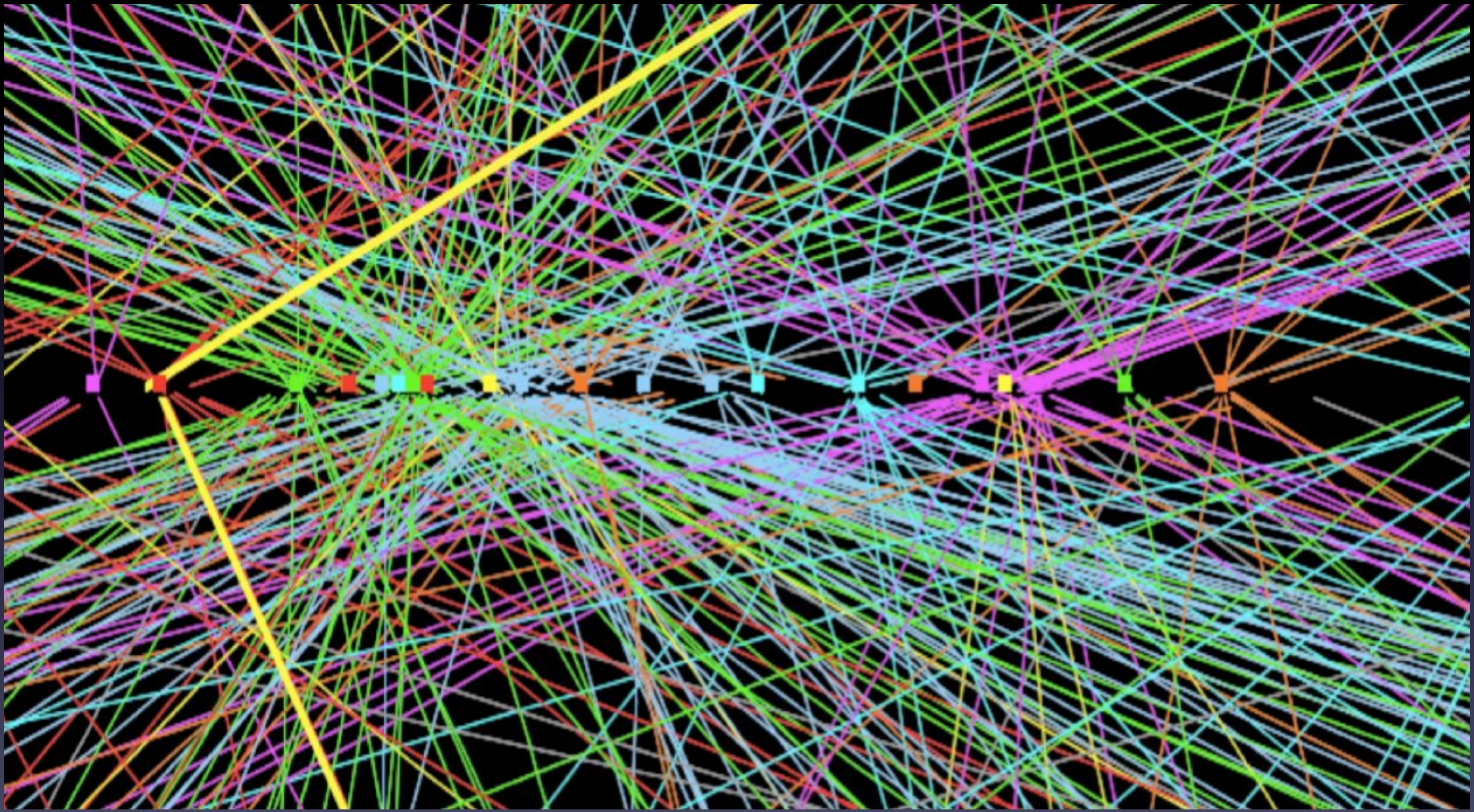
- in the experiments at each crossing:
  ~ 20-50 proton-proton collisions
  ~ 1500 particles produced

- 1 billion interactions / second

- impossible to record everything !

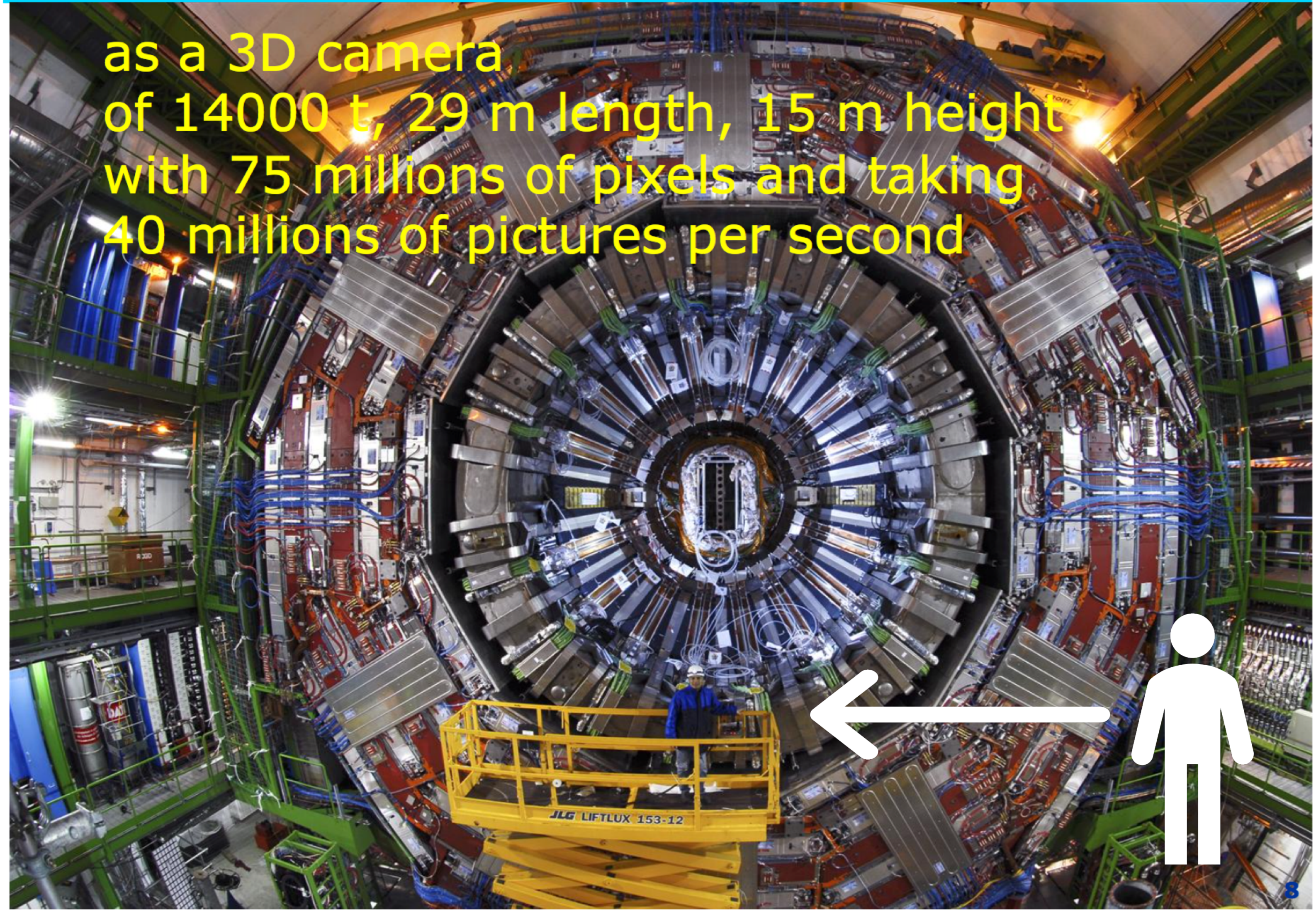
- a Higgs boson to find within 5 billions of collisions…

Un evento: ~20 urti, ogni traccia una particella

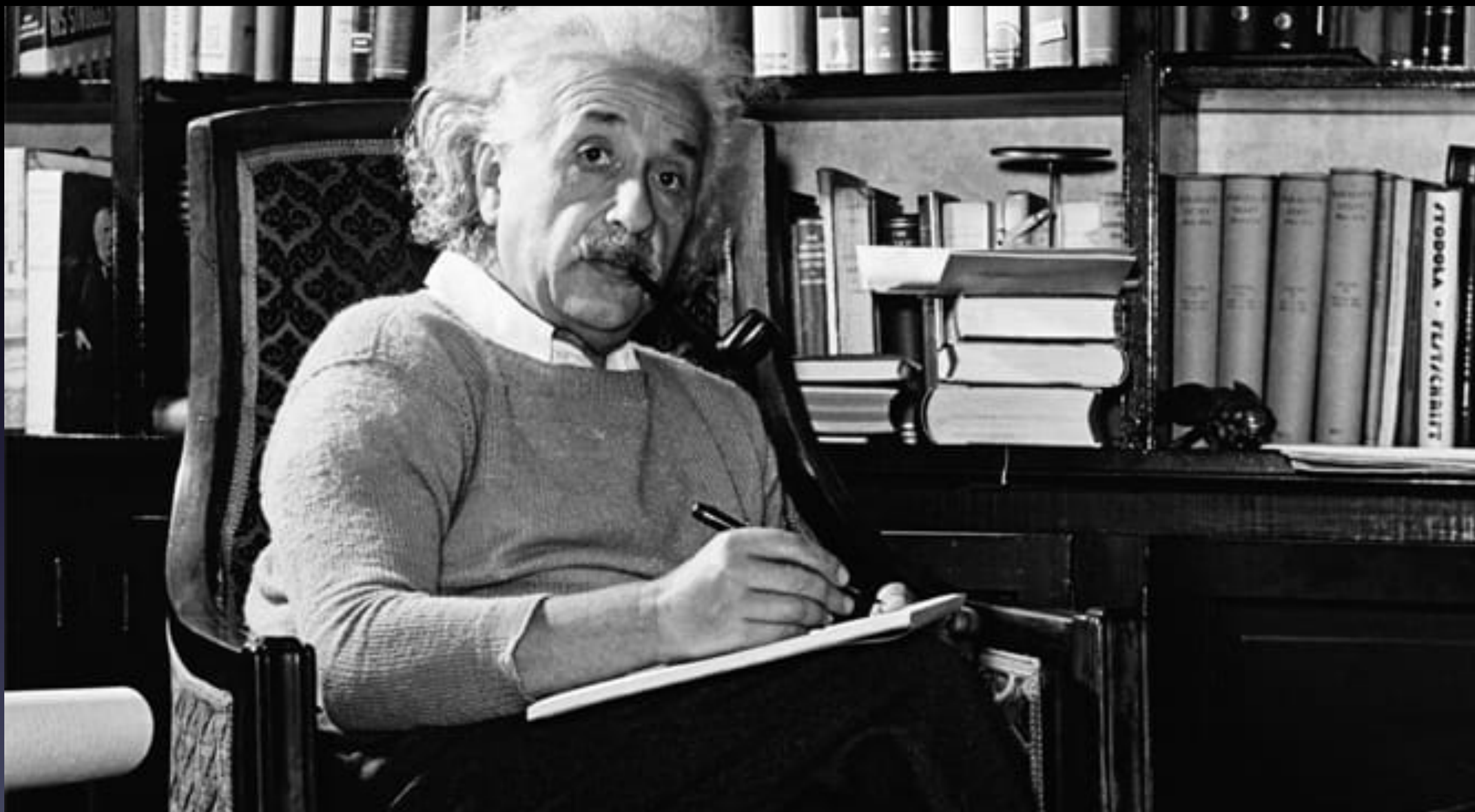


the CMS detector

as a 3D camera
of 14000 t, 29 m length, 15 m height
with 75 millions of pixels and taking
40 millions of pictures per second



Farò il teorico, come Einstein…



TTP00–20
hep-ph/0008287
August 2000

Two-Loop Master Integrals for $\gamma^* \to 3$ Jets: The planar topologies

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[b] *Dipartimento di Fisica, Università di Bologna and INFN, Sezione di Bologna, I-40126 Bologna, Italy*

Agosto 2000

$$= \left(\frac{S_\epsilon}{16\pi^2}\right)^2 \frac{(-s_{123})^{-2\epsilon}}{s_{12}+s_{13}} \sum_{i=-1}^{3} \frac{f_{5.1,i}\left(\frac{s_{13}}{s_{123}},\frac{s_{23}}{s_{123}}\right)}{\epsilon^i} + \mathcal{O}(\epsilon^2), \qquad (4.20)$$

with:

$$f_{5.1,3}(y,z) = 0\,, \qquad (4.21)$$

$$f_{5.1,2}(y,z) = -H(0;z)\,, \qquad (4.22)$$

$$f_{5.1,1}(y,z) = +H(0;y)H(0;z) - 2H(0;z) + 2H(0,0;z) + H(1,0;z) + \frac{\pi^2}{6}\,, \qquad (4.23)$$

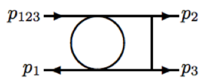
$$\begin{aligned} f_{5.1,0}(y,z) = {} & +2H(0;y)H(0;z) - 2H(0;y)H(1,0;z) - 4H(0;z) - H(0;z)H(1-z,0;y) \\ & -2H(0,0;y)H(0;z) + 4H(0,0;z) - 2H(0,0;z)H(0;y) - 4H(0,0,0;z) - H(0,1,0;y) \\ & -2H(0,1,0;z) + 2H(1,0;z) - H(1,0;z)H(1-z;y) - 2H(1,0,0;z) - 2H(1,1,0;z) \\ & -H(1-z,1,0;y) + \frac{\pi^2}{6}\left[+2 - 2H(0;y) - 3H(0;z) - 2H(1;z) - H(1-z;y)\right]\,, \end{aligned} \qquad (4.24)$$

$$\begin{aligned} f_{5.1,-1}(y,z) = {} & +4H(0;y)H(0;z) - 4H(0;y)H(1,0;z) + 4H(0;y)H(1,0,0;z) + 4H(0;y)H(1,1,0;z) \\ & -8H(0;z) - 2H(0;z)H(1-z,0;y) + 2H(0;z)H(1-z,0,0;y) \\ & +H(0;z)H(1-z,1-z,0;y) - 4H(0,0;y)H(0;z) + 4H(0,0;y)H(0,0;z) \\ & +4H(0,0;y)H(1,0;z) + 8H(0,0;z) - 4H(0,0;z)H(0;y) + 2H(0,0;z)H(1-z,0;y) \\ & +4H(0,0,0;y)H(0;z) - 8H(0,0,0;z) + 4H(0,0,0;z)H(0;y) + 8H(0,0,0,0;z) \\ & +2H(0,0,1,0;y) + 4H(0,0,1,0;z) - 2H(0,1,0;y) - 4H(0,1,0;z) \\ & +4H(0,1,0;z)H(0;y) + 2H(0,1,0;z)H(1-z;y) + 2H(0,1,0,0;y) + 4H(0,1,0,0;z) \end{aligned}$$

Per arrivare a queste formule
sono stati necessari
mesi di tempo
macchina

$$-H(0,1,1,0;y)+4H(0,1,1,0;z)+2H(0,1-z;y)H(1,0;z)$$
$$+2H(0,1-z,0;y)H(0;z)+2H(0,1-z,1,0;y)+4H(1,0;z)-2H(1,0;z)H(1-z;y)$$
$$+2H(1,0;z)H(1-z,0;y)+H(1,0;z)H(1-z,1-z;y)-4H(1,0,0;z)$$
$$+2H(1,0,0;z)H(1-z;y)+4H(1,0,0,0;z)+4H(1,0,1,0;z)-4H(1,1,0;z)$$
$$+2H(1,1,0;z)H(1-z;y)+4H(1,1,0,0;z)+4H(1,1,1,0;z)+H(1-z,0,1,0;y)$$
$$-2H(1-z,1,0;y)+2H(1-z,1,0,0;y)-H(1-z,1,1,0;y)+H(1-z,1-z,1,0;y)$$
$$+\frac{7\pi^4}{90}+5\zeta_3 H(0;z)$$
$$+\frac{\pi^2}{6}\Big[+4-4H(0;y)+4H(0;y)H(0;z)+4H(0;y)H(1;z)-6H(0;z)$$
$$+H(0;z)H(1-z;y)+4H(0,0;y)+6H(0,0;z)-H(0,1;y$$
$$+2H(0,1-z;y)-4H(1;z)+2H(1;z)H(1-z;y)+4H(1,$$
$$-2H(1-z;y)+2H(1-z,0;y)-H(1-z,1;y)+H(1-z$$

Ognuno degli H(…) è una funzione da valutare numericamente



$$=\left(\frac{S_\epsilon}{16\pi^2}\right)^2\frac{(-s_{123})^{-2\epsilon}}{s_{23}}\sum_{i=-1}^{3}\frac{f_{5.2,i}\left(\frac{s_{13}}{s_{123}},\frac{s_{23}}{s_{123}}\right)}{\epsilon^i}+\mathcal{O}(\epsilon^2), \tag{4.26}$$

with:

$$f_{5.2,3}(y,z) = -1\,, \tag{4.27}$$
$$f_{5.2,2}(y,z) = -2+H(0;y)+H(0;z)\,, \tag{4.28}$$
$$f_{5.2,1}(y,z) = -4+2H(0;y)-H(0;y)H(0;z)+2H(0;z)-2H(0,0;y)-H(0,0;z)-H(1,0;y)\,, \tag{4.29}$$
$$\begin{aligned}f_{5.2,0}(y,z) = {}& -8+4H(0;y)-2H(0;y)H(0;z)+H(0;y)H(1,0;z)+4H(0;z)+H(0;z)H(1-z,0;y)\\ &-4H(0,0;y)+2H(0,0;y)H(0;z)-2H(0,0;z)+H(0,0;z)H(0;y)+4H(0,0,0;y)\\ &+H(0,0,0;z)+2H(0,1,0;y)-2H(1,0;y)+H(1,0;z)H(1-z;y)+2H(1,0,0;y)\\ &+H(1,1,0;z)+H(1-z,1,0;y)+5\zeta_3+\frac{\pi^2}{6}\left[+H(0;y)+H(1;z)+H(1-z;y)\right]\,,\end{aligned} \tag{4.30}$$
$$\begin{aligned}f_{5.2,-1}(y,z) = {}& -16+8H(0;y)-4H(0;y)H(0;z)+2H(0;y)H(1,0;z)-H(0;y)H(1,0,0;z)\\ &-H(0;y)H(1,1,0;z)+8H(0;z)+2H(0;z)H(1-z,0;y)-2H(0;z)H(1-z,0,0;y)\\ &-H(0;z)H(1-z,1-z,0;y)-8H(0,0;y)+4H(0,0;y)H(0;z)-2H(0,0;y)H(0,0;z)\\ &-2H(0,0;y)H(1,0;z)-4H(0,0;z)+2H(0,0;z)H(0;y)-H(0,0;z)H(1-z,0;y)\\ &+8H(0,0,0;y)-4H(0,0,0;y)H(0;z)+2H(0,0,0;z)-H(0,0,0;z)H(0;y)\\ &-8H(0,0,0,0;y)-H(0,0,0,0;z)-4H(0,0,1,0;y)+4H(0,1,0;y)\\ &-H(0,1,0;z)H(0;y)-H(0,1,0;z)H(1-z;y)-4H(0,1,0,0;y)-H(0,1,1,0;z)\\ &-2H(0,1-z;y)H(1,0;z)-2H(0,1-z,0;y)H(0;z)-2H(0,1-z,1,0;y)\\ &-4H(1,0;y)+2H(1,0;z)H(1-z;y)-H(1,0;z)H(1-z,0;y)\\ &-H(1,0;z)H(1-z,1-z;y)+4H(1,0,0;y)-H(1,0,0;z)H(1-z;y)\\ &-4H(1,0,0,0;y)-H(1,0,1,0;z)+2H(1,1,0;z)-H(1,1,0,0;z)\end{aligned}$$

9

$$-2H(1-z,0,1,0;y)+2H(1-z,1,0;y)-2H(1-z,1,0,0;y)$$
$$-H(1-z,1-z,1,0;y)+\frac{37\pi^4}{360}+\zeta_3\left[10-6H(0;y)-5H(0;z)-H(1;z)-H(1-z;y)\right]$$
$$+\frac{\pi^2}{6}\Big[+2H(0;y)-H(0;y)H(0;z)-H(0;y)H(1;z)-H(0;z)H(1-z;y)$$
$$-2H(0,0;y)-H(0,1;z)-2H(0,1-z;y)+2H(1;z)$$
$$-H(1,0;z)+2H(1-z;y)-H(1-z,0;y)-H(1-z,1-z;y)\Big]\,. \tag{4.31}$$

Risolvere numericamente un problema richiede
la capacità di spezzarlo in parti più semplici,
di individuare i passi per ottenere la risposta,
di controllare la correttezza di ogni passo

Non vi laureerete senza imparare a programmare

Cominciamo subito