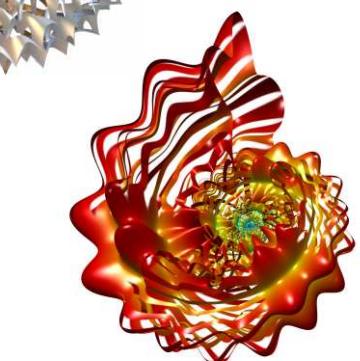
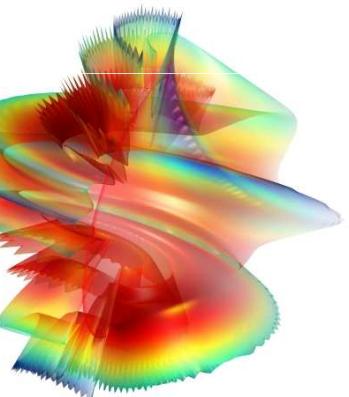
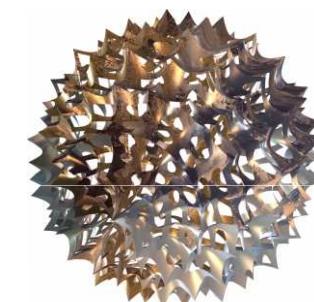
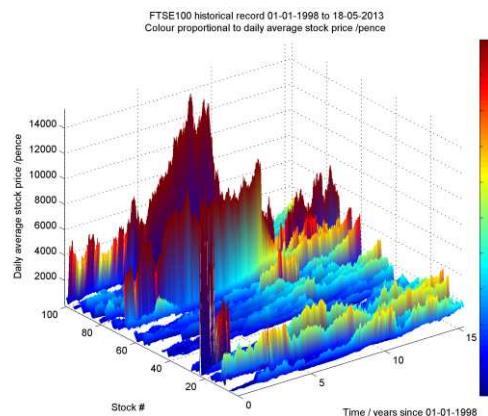
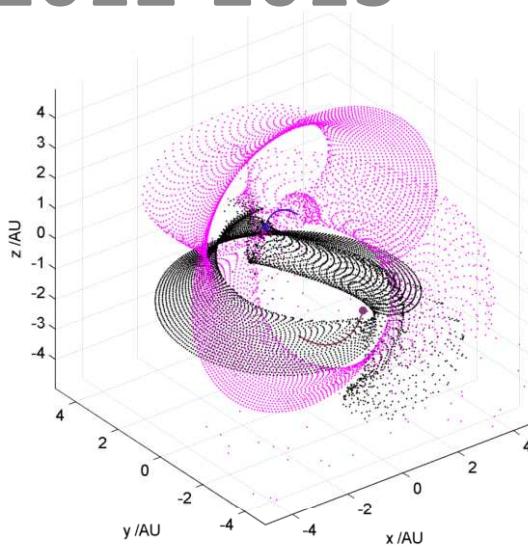
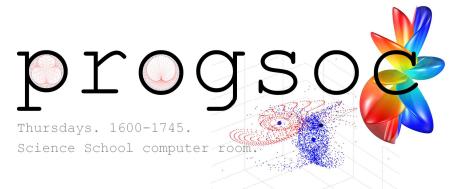
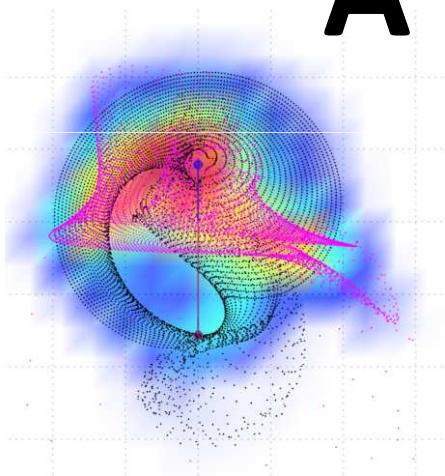


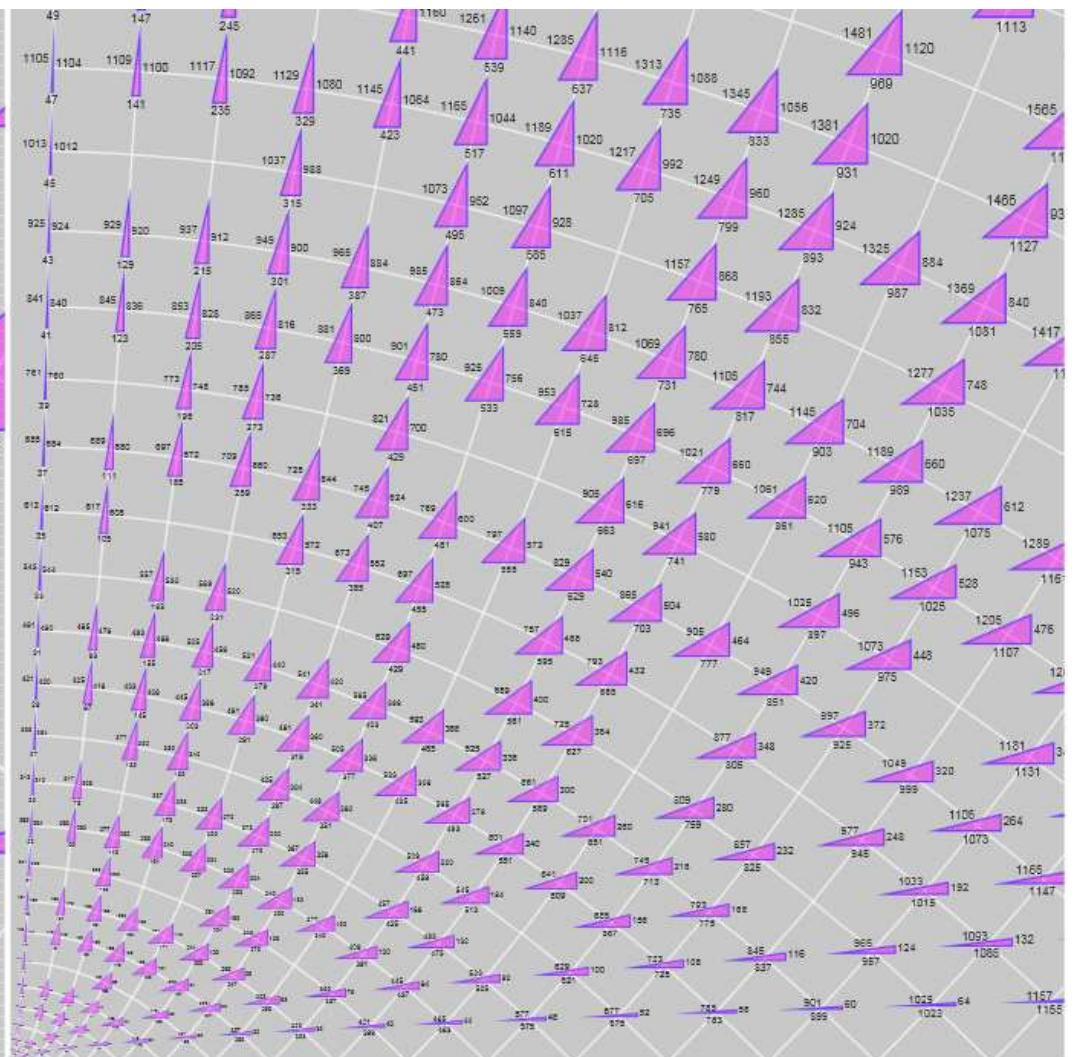
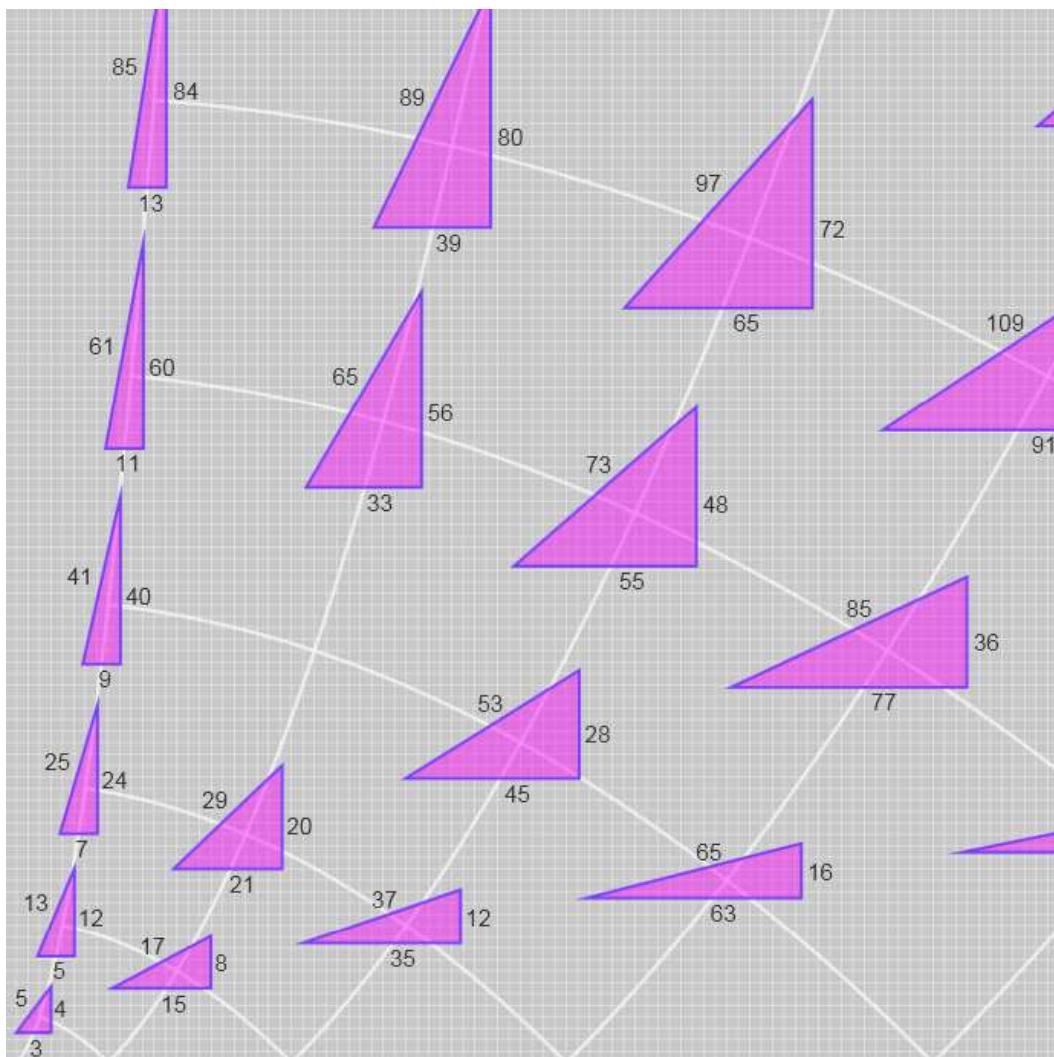
# A mathematical mezze

AF 2012-2013



$\mu$ athematicon

# 1. Pythagorean triples

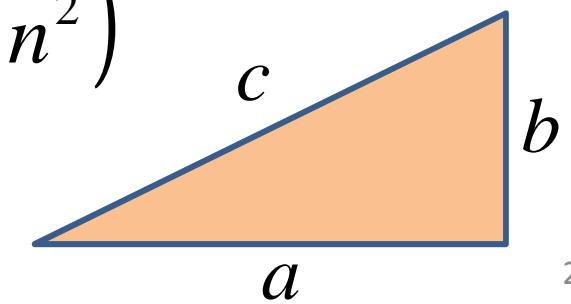


$$a = k(m^2 - n^2)$$

$$b = 2kmn$$

$$c = k(m^2 + n^2)$$

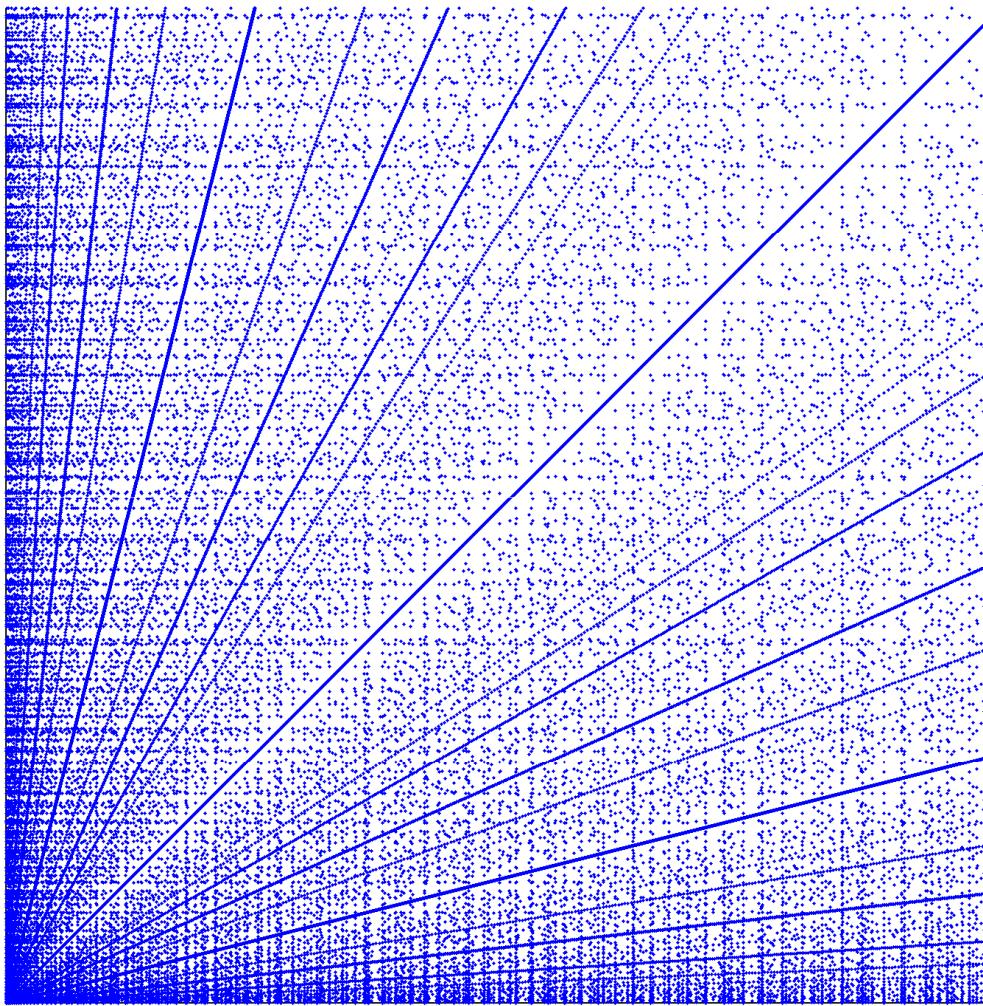
$$c^2 = a^2 + b^2$$



multiply grid for 1 : 20. Rule = square highlighted  
Number of elements obeying rule = 42 (10.5%)

20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	400	
19	38	57	76	95	114	133	152	171	190	209	228	247	266	285	304	323	342	361	380	
18	38	54	72	90	108	126	144	162	180	198	216	234	252	270	288	306	324	342	360	
17	34	51	68	85	102	119	136	153	170	187	204	221	238	255	272	289	304	320		
16	32	48	64	80	96	112	128	144	160	176	192	208	224	240	256	272	288	304	320	
15	30	45	60	75	90	105	120	135	150	165	180	195	210	225	240	255	270	285	300	
14	28	42	56	70	84	98	112	126	140	154	168	182	196	210	224	238	252	266	280	
13	26	39	52	65	78	91	104	117	130	143	156	170	182	195	208	221	234	247	260	
12	24	36	48	60	72	84	96	108	120	132	144	156	168	180	192	204	216	228	240	
11	22	33	44	55	66	77	88	99	110	121	132	143	154	165	176	187	198	209	220	
10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	
9	18	27	36	45	54	63	72	81	90	99	108	117	126	135	144	153	162	171	180	
8	16	24	32	40	48	56	64	72	80	88	96	104	112	120	128	136	144	152	160	
7	14	21	28	35	42	49	56	63	70	77	84	91	98	105	112	119	126	133	140	
6	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120	
5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	
4	8	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	
3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	
2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	
1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

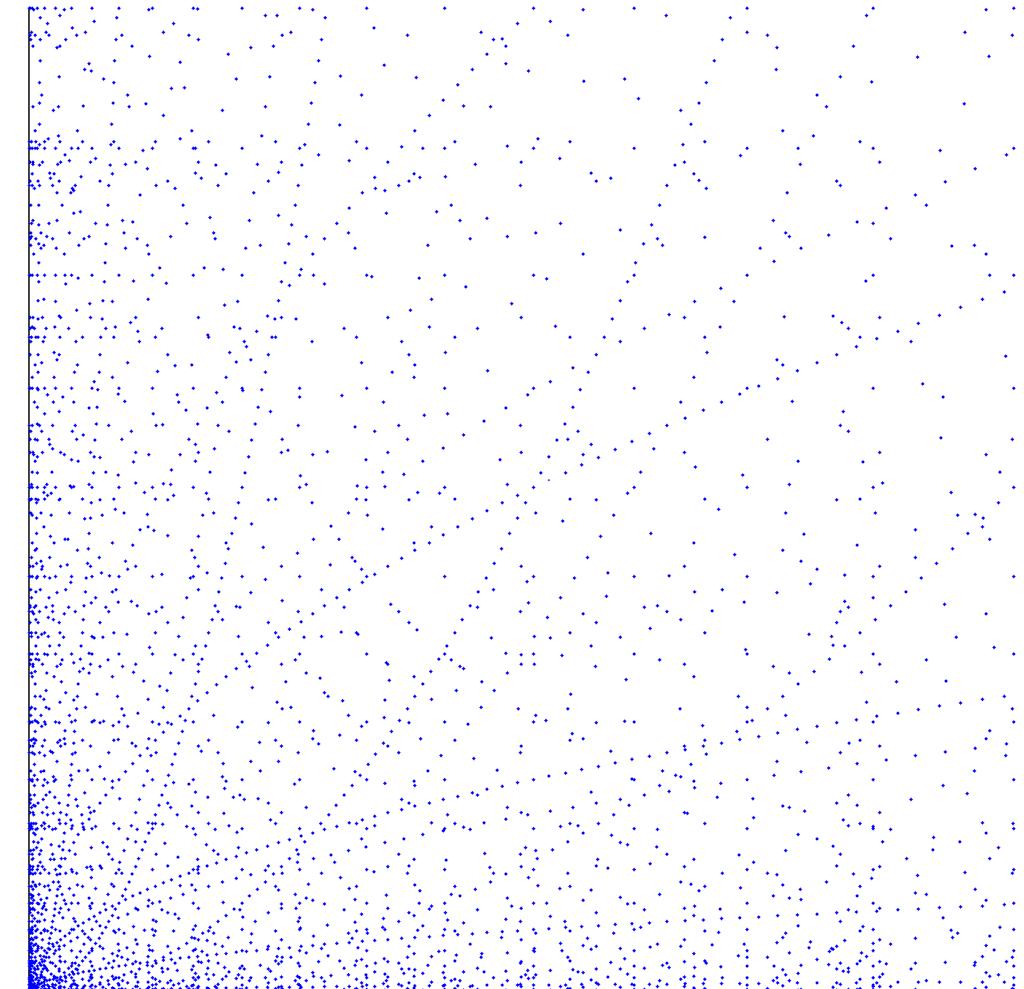
multiply grid for 1 : 8000. Rule = square highlighted  
Number of elements obeying rule = 44872 (0.070112%)



## 2.

# Squares and Cubes

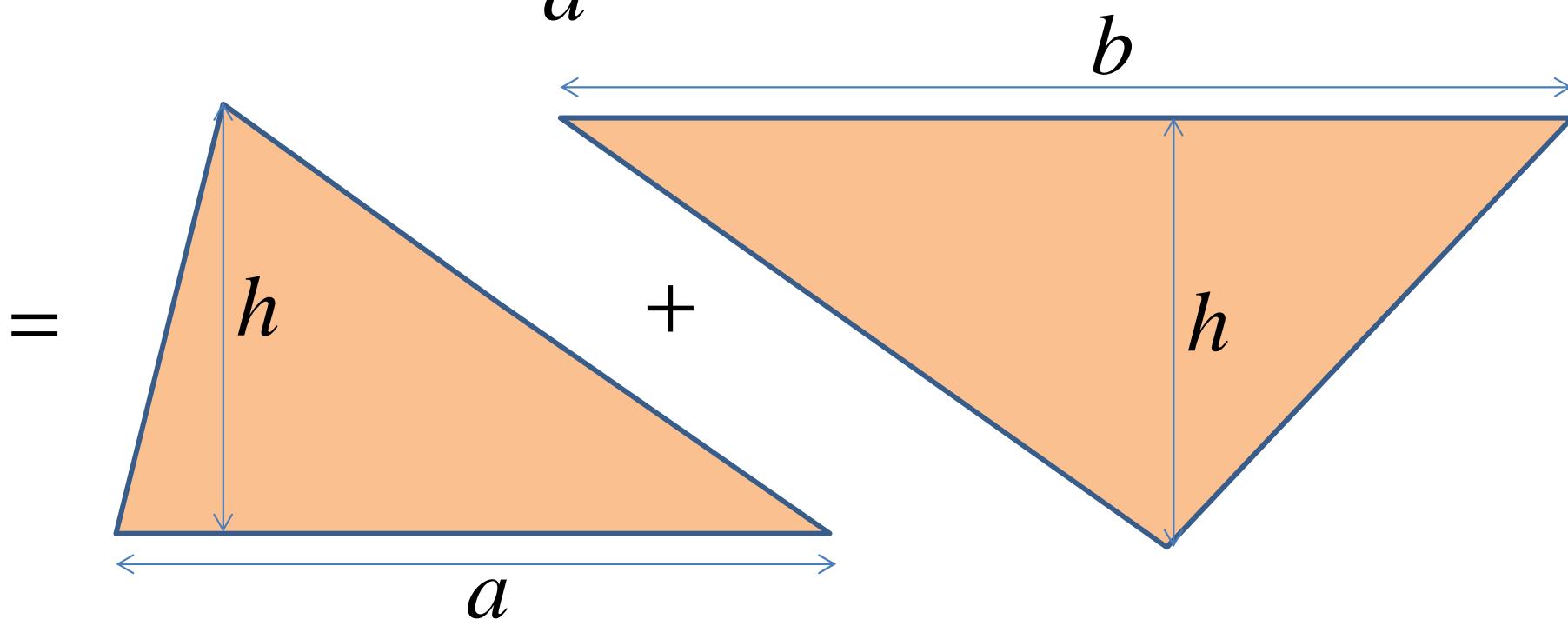
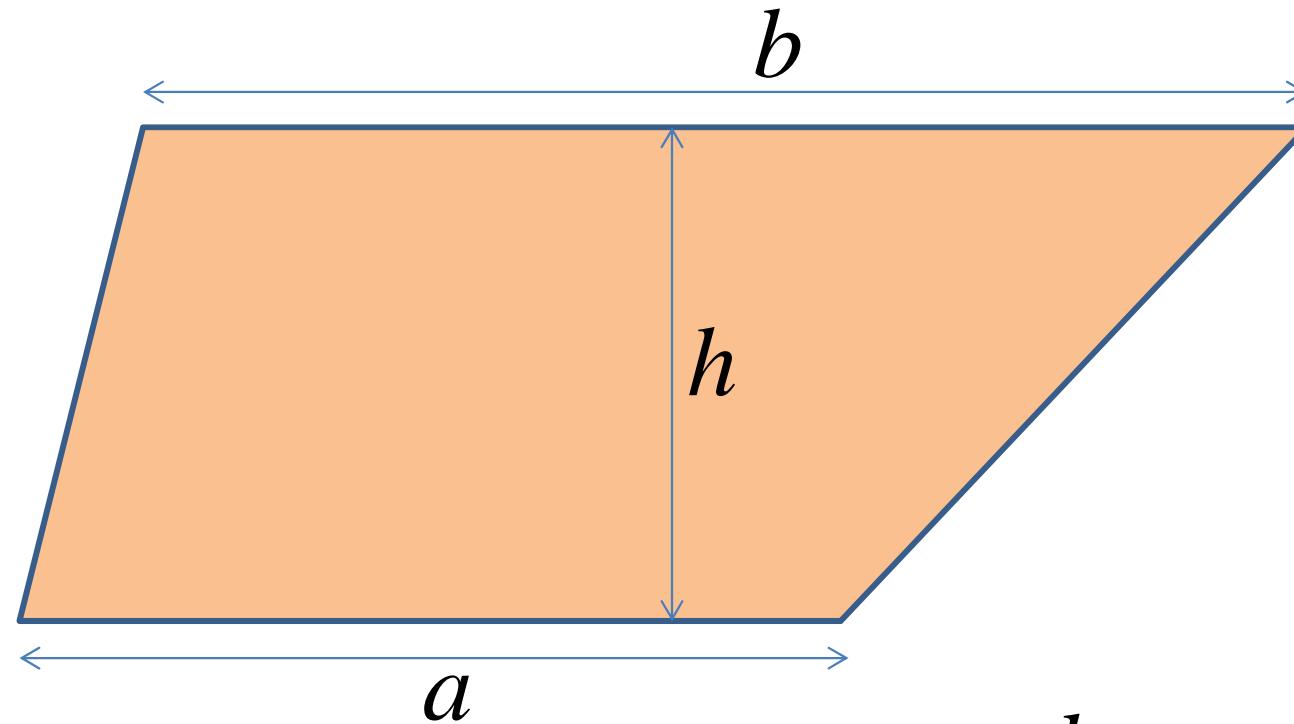
multiply grid for 1 : 8000. Rule = cube highlighted  
Number of elements obeying rule = 3154 (0.0049281%)



3.

## Area of a trapezium

$$A = \frac{1}{2}(a+b)h$$



## 4. Cipher

The Comedy of Errors by William Shakespeare

ACT I

SCENE I. A hall in DUKE SOLINUS'S palace.

Enter DUKE SOLINUS, AEGEON, Gaoler, Officers,  
and other Attendants

AEGEON

Proceed, Solinus, to procure my fall  
And by the doom of death end woes and all.



Uif Dpnfez pg Fsspst cz Xjmmjbn Tiblftqfbsf

BDU J

TDFOF J£ B ibmm jo EVLF TPMJOVT'T qbmbdf£

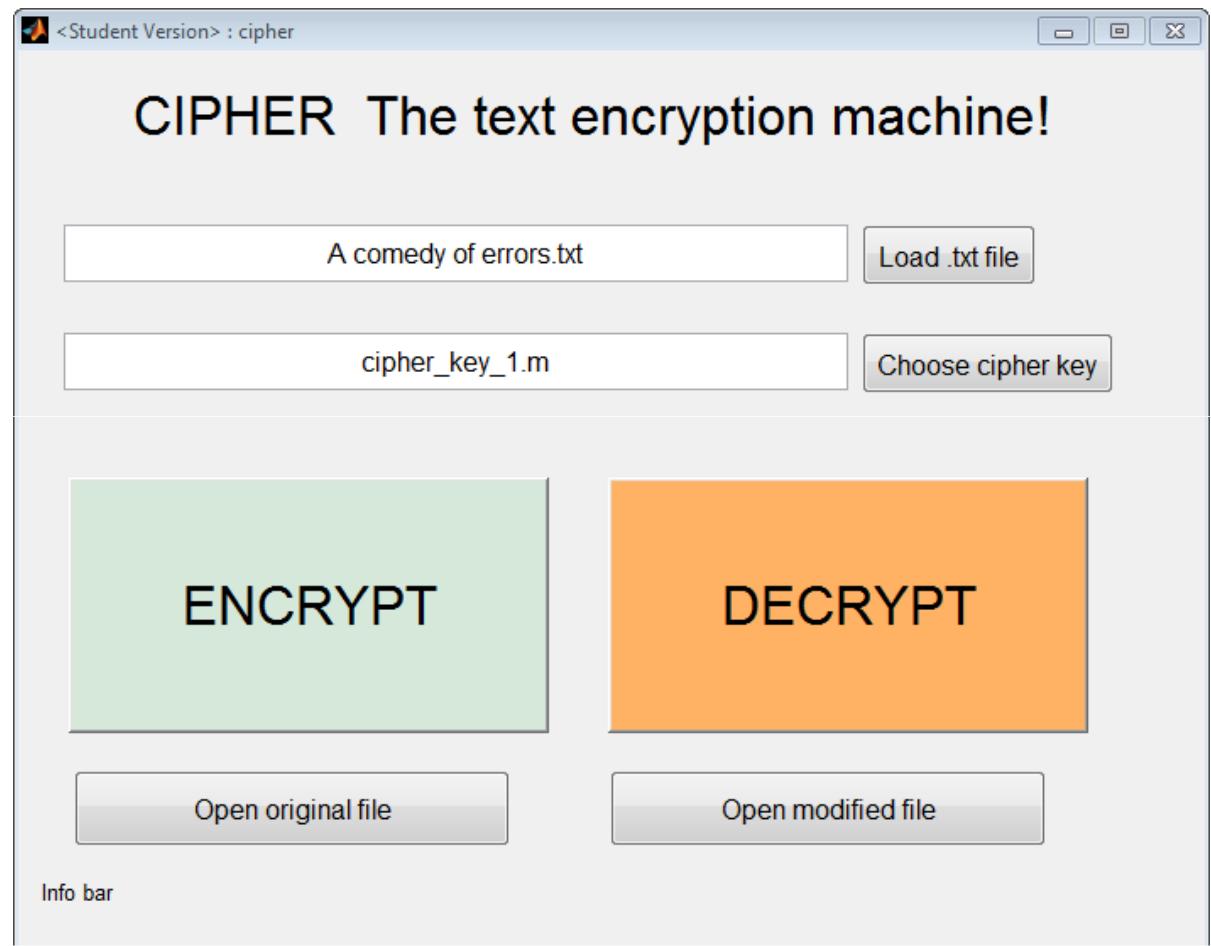
Foufs EVLF TPMJOVT, BFHFPO, Hbpmfs, Pggjdfst, boe puifs

Buufoebout

BFHFPO

Qspdffe, Tpmjovt, up qspdvsf nz gbmm

Boe cz uif eppn pg efbui foe xpft boe bmm£

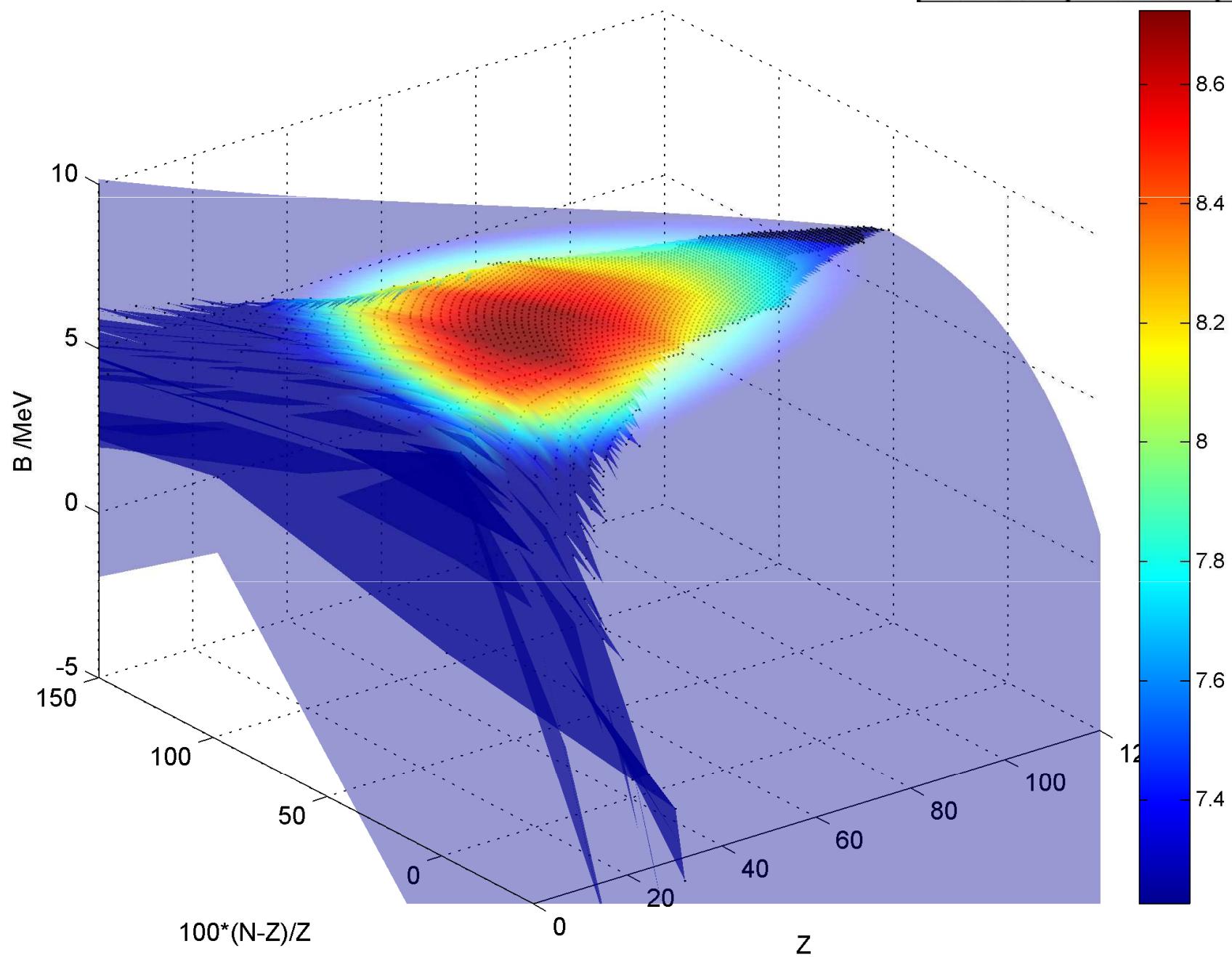


5.

## Nuclear binding energy

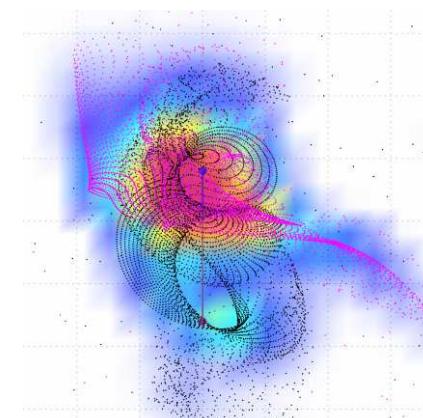
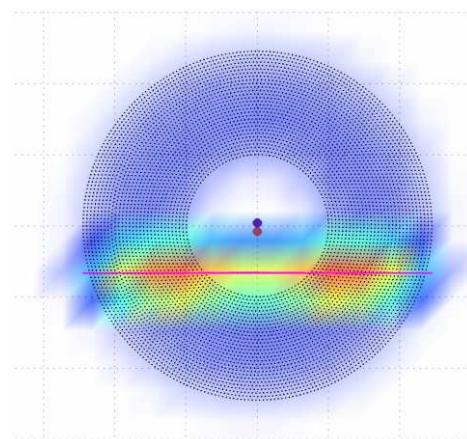
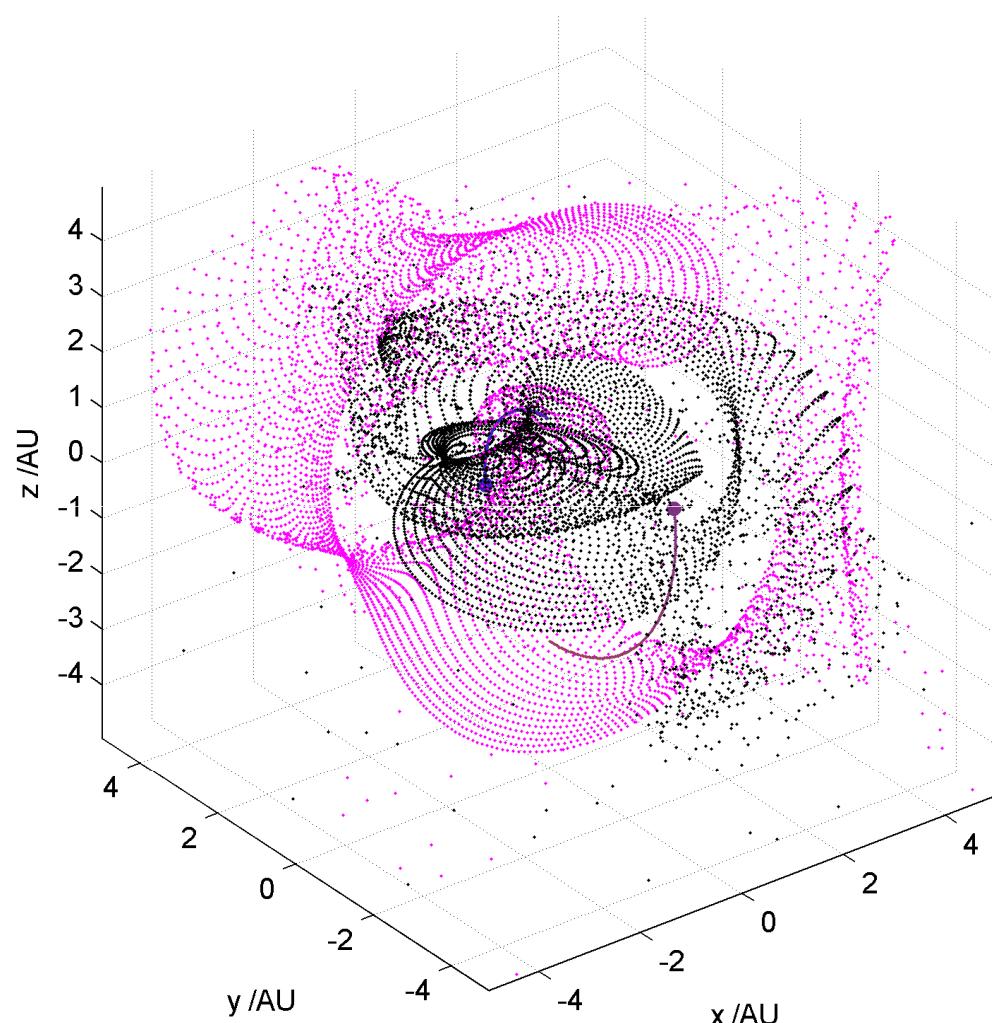
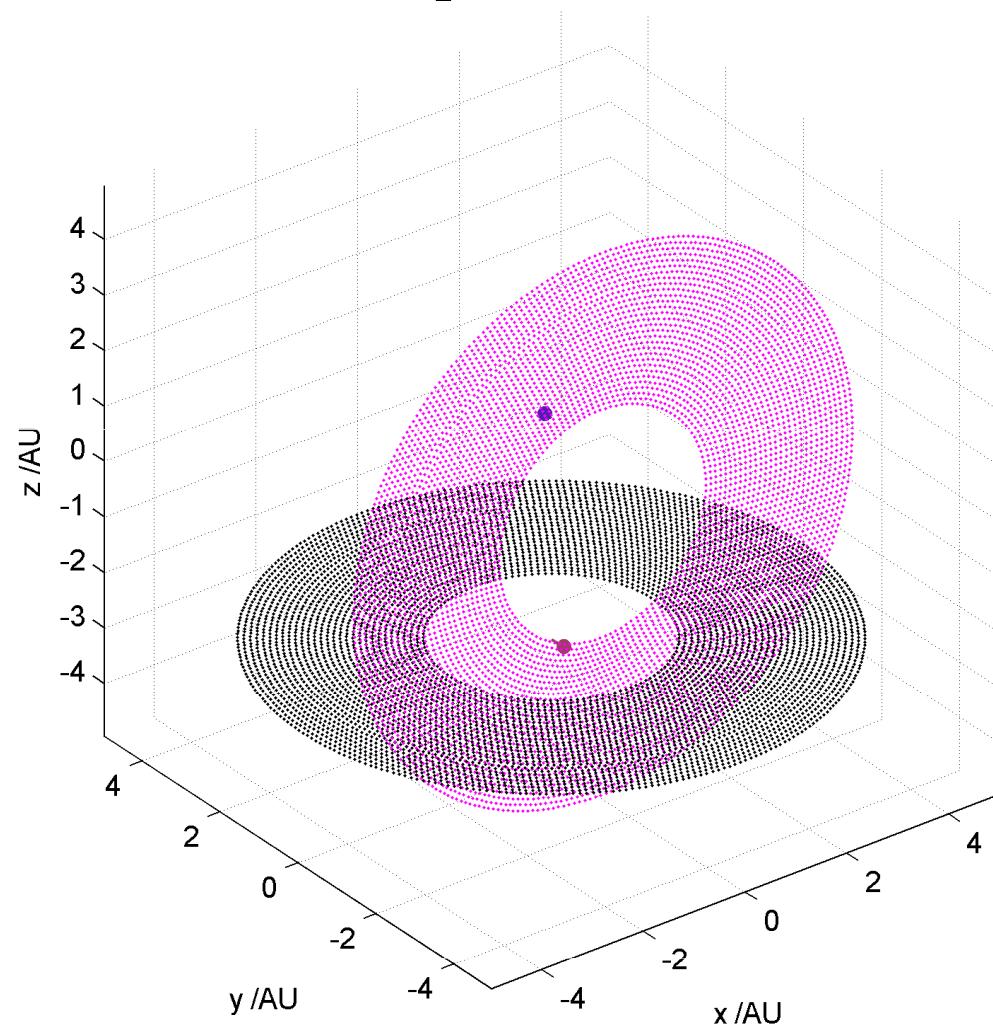
carbon 6 <b>C</b> 12.011	nitrogen 7 <b>N</b> 14.007	oxygen 8 <b>O</b> 15.999
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Nuclear Binding Energy per nucleon /MeV



6.

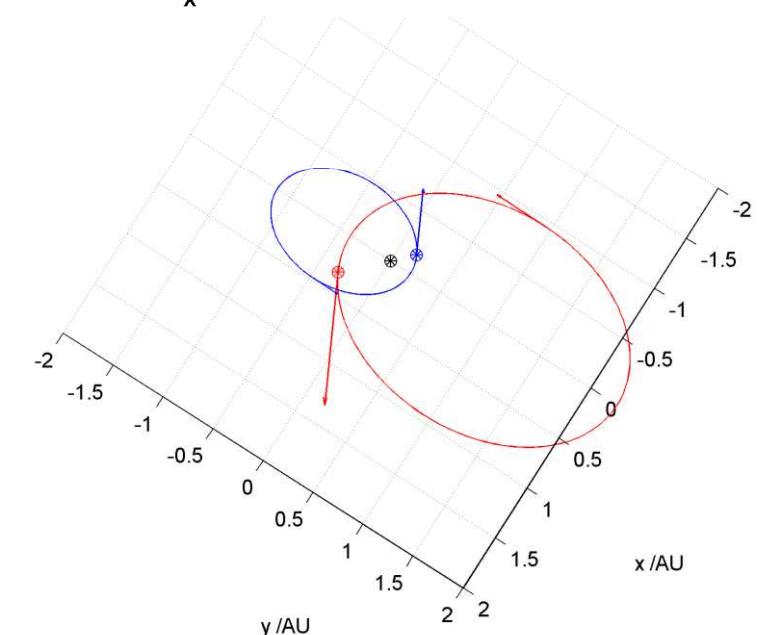
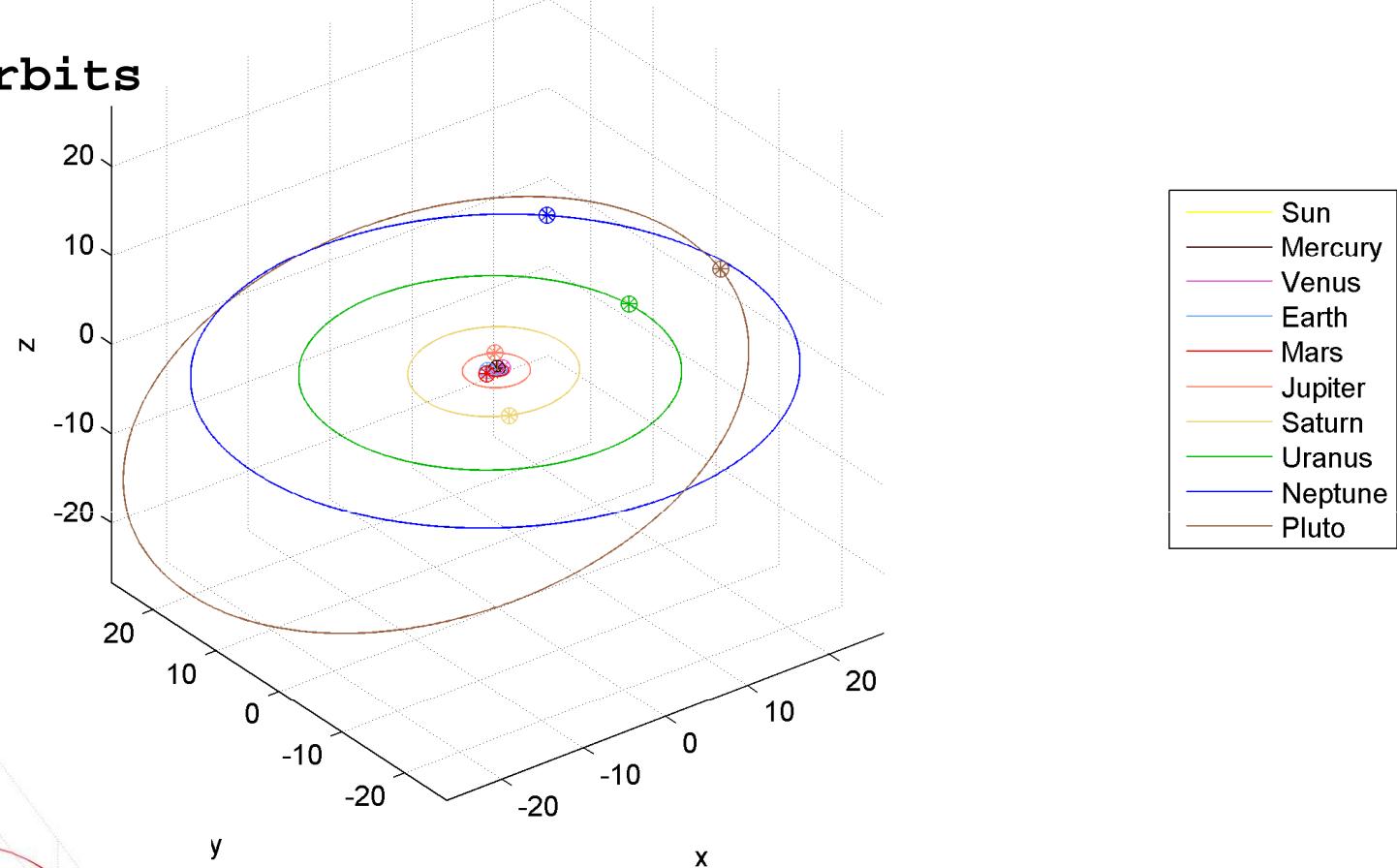
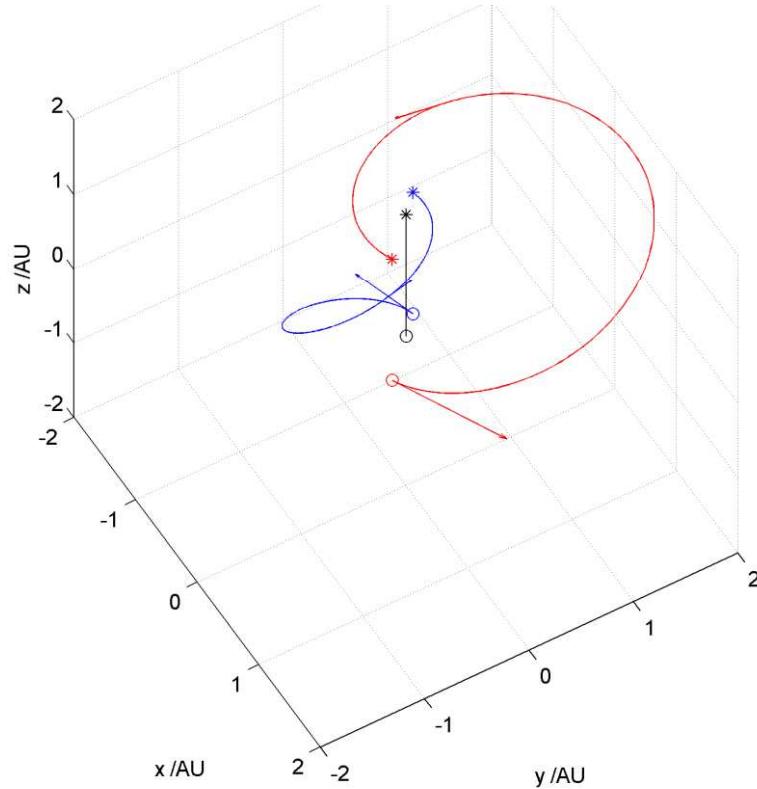
## Gravity Simulation



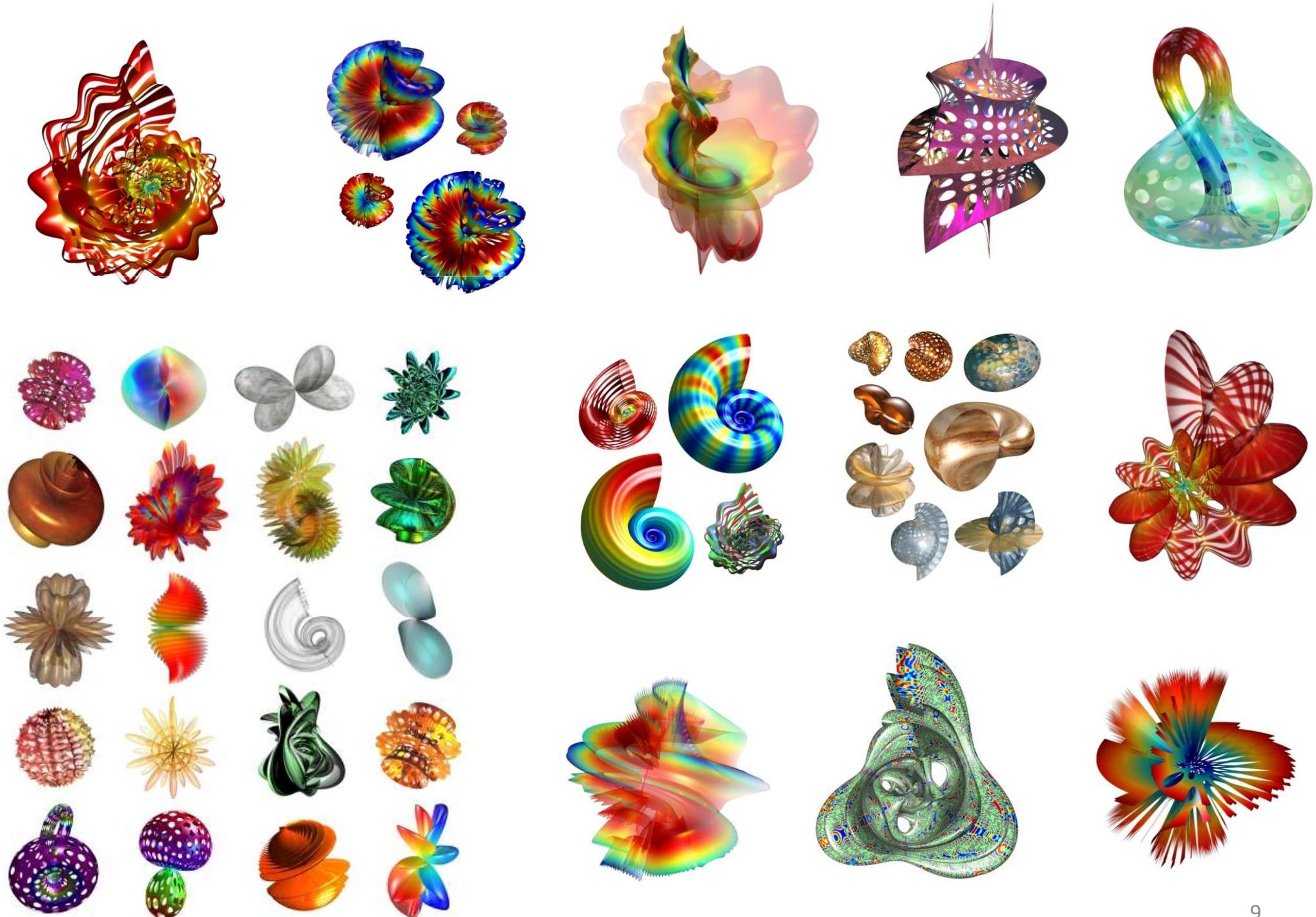
## 7. Elliptical orbits

$$r = \frac{a(1 - \varepsilon^2)}{1 + \varepsilon \cos \theta}$$

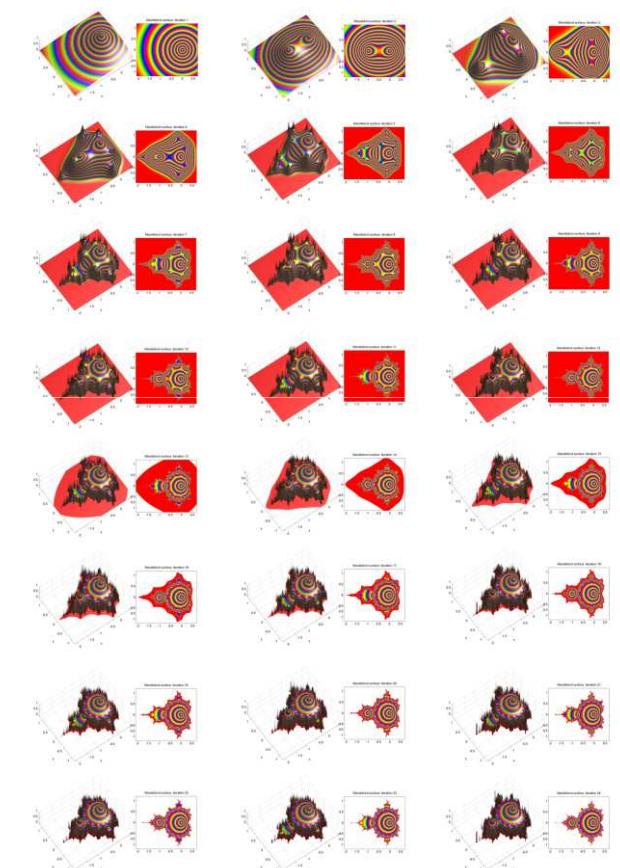
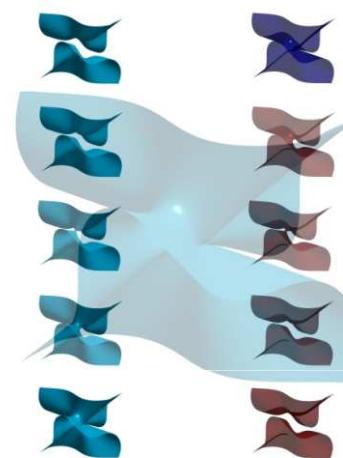
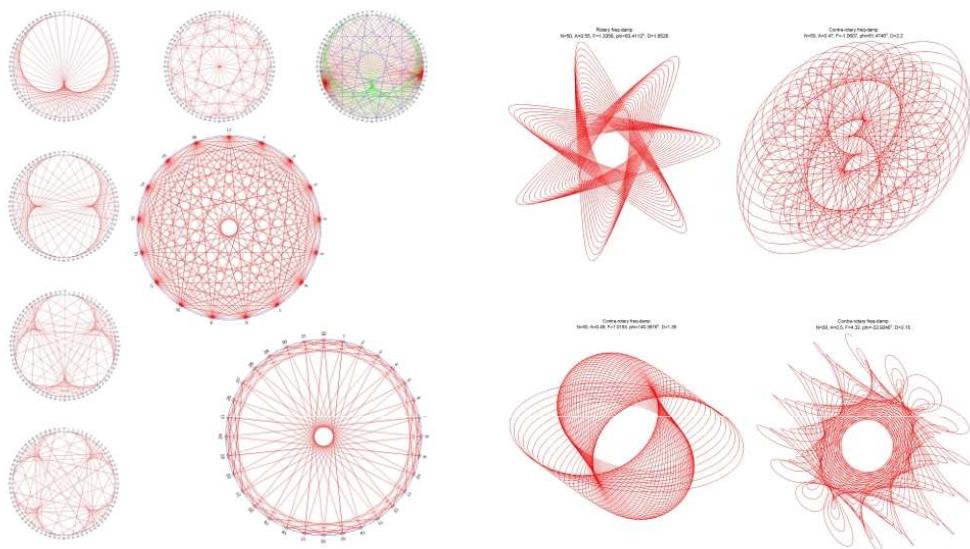
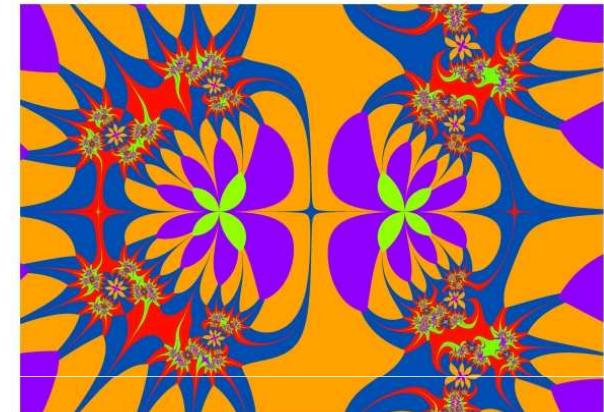
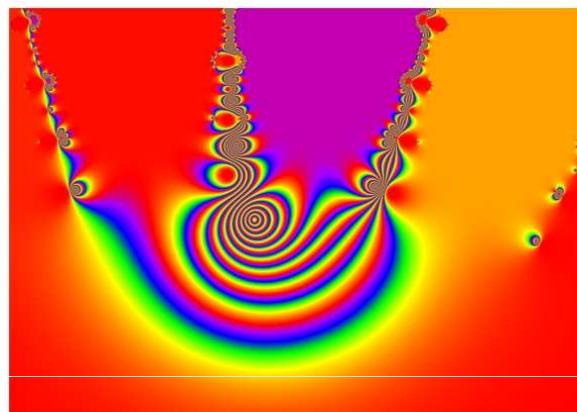
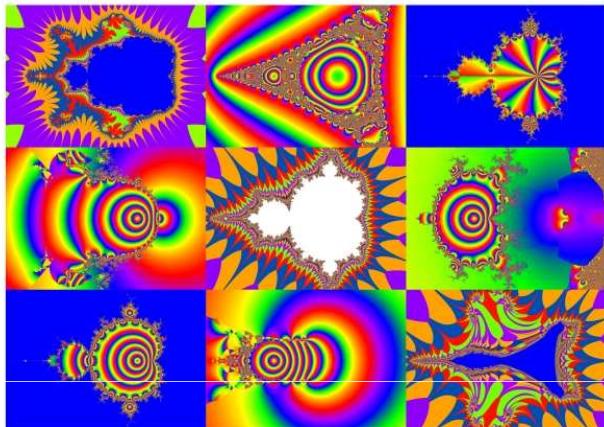
$$\varepsilon = \sqrt{1 - \frac{b^2}{a^2}}$$



## 8. Mathematicon Exhibition

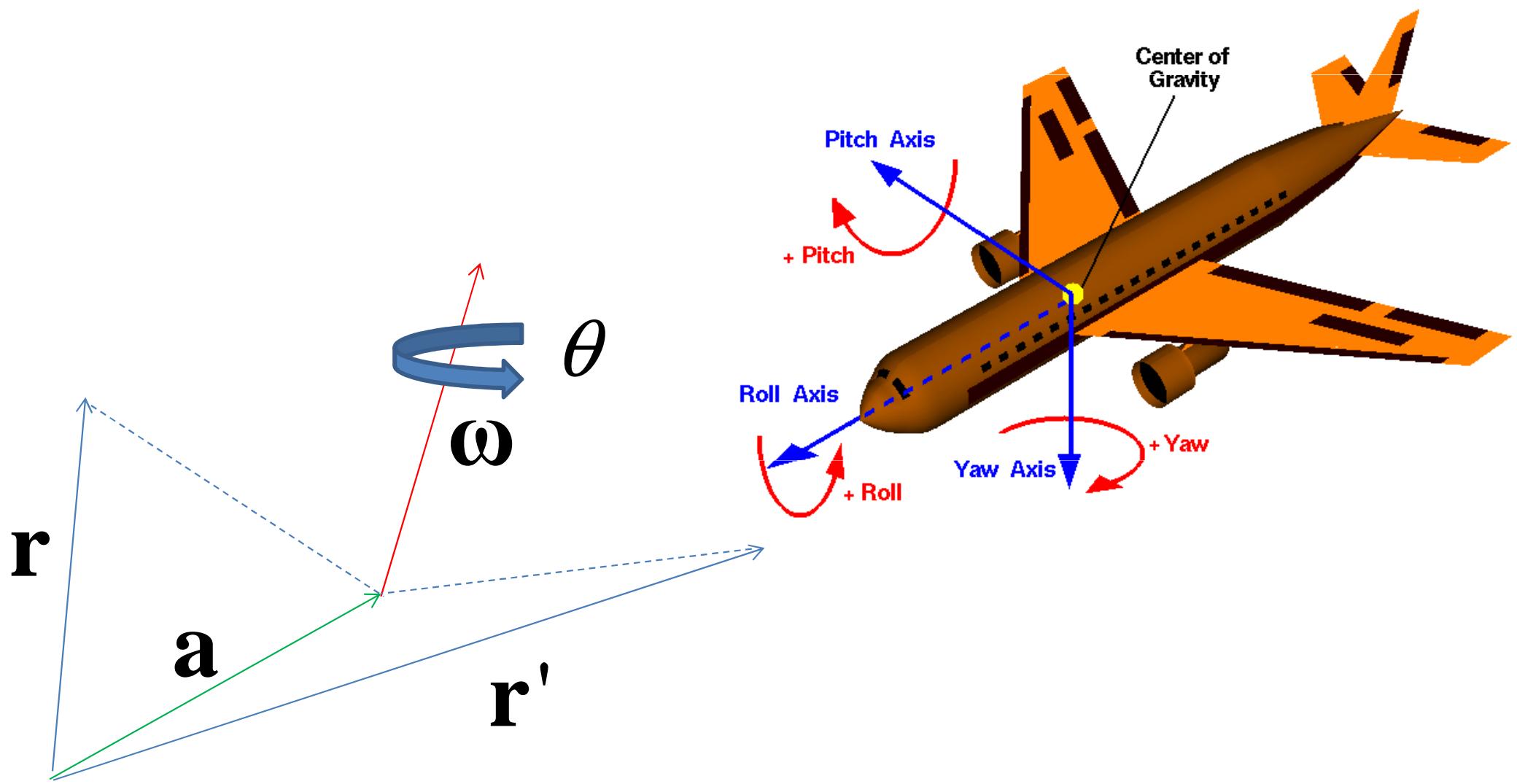


## 8. Mathematicon Exhibition



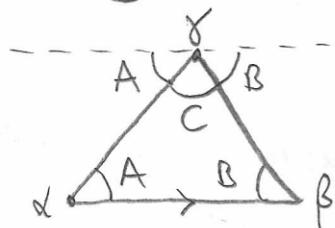
## 9. Rodriguez's rotation formula

$$\mathbf{r}' = \mathbf{a} (1 - \cos \theta) + \mathbf{r} \cos \theta + \frac{\boldsymbol{\omega} \times (\mathbf{r} - \mathbf{a})}{|\boldsymbol{\omega}|} \sin \theta + \frac{(\mathbf{r} \cdot \boldsymbol{\omega} - \mathbf{a} \cdot \boldsymbol{\omega})(1 - \cos \theta)}{|\boldsymbol{\omega}|^2} \boldsymbol{\omega}$$

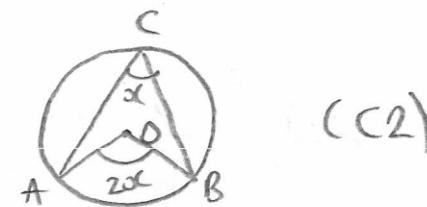


## 10. Circle theorems

Firstly we must prove the interior angles of a triangle sum to  $180^\circ$  (C1)

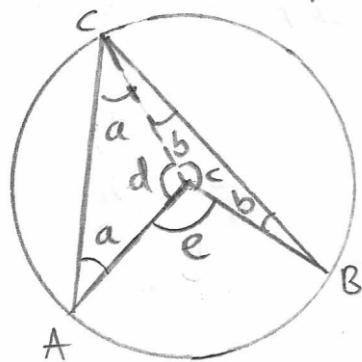


This can be achieved by drawing a line through the vertex of angle  $C$  ( $x$ ) which is  $\parallel$  to line  $AB$



(C2)

Next we will prove the "Arrowhead theorem"



Split the arrowhead into two ISOSCELES triangles. Using (C1)

$$2a + d = 180^\circ \quad (1)$$

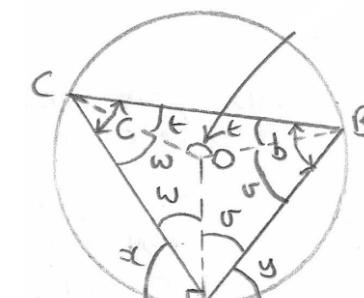
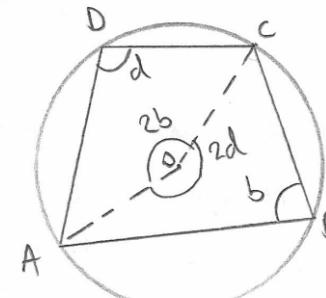
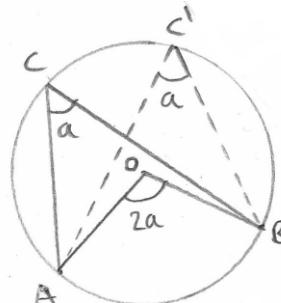
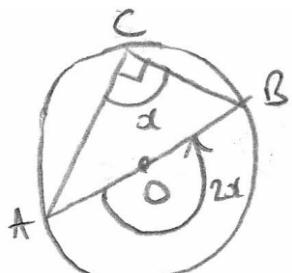
$$2b + c = 180^\circ \quad (2) \text{ and also}$$

$$d + c + e = 360^\circ \quad (3)$$

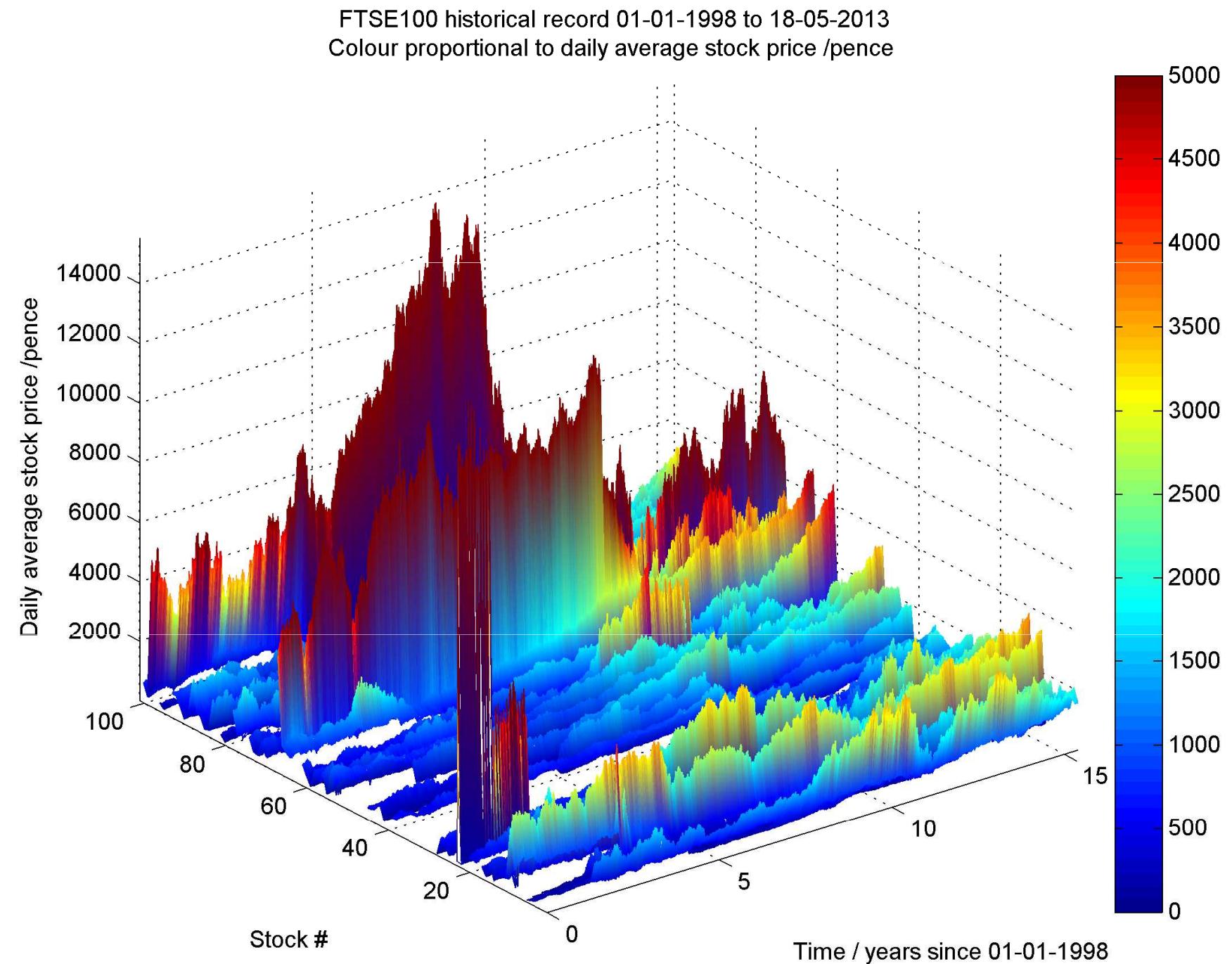
$$\therefore (1) + (2) = (3) \Rightarrow 2a + 2b + d + e = d + c + e$$

$$\Rightarrow \boxed{2(a+b) = e}$$

which proves the theorem



## 11. FTSE 100 stocks and shares



12. A most intriguing integral

$$\boxed{\int_0^\infty \frac{2x \sin x}{1+x^2} dx = \frac{\pi}{e}}$$

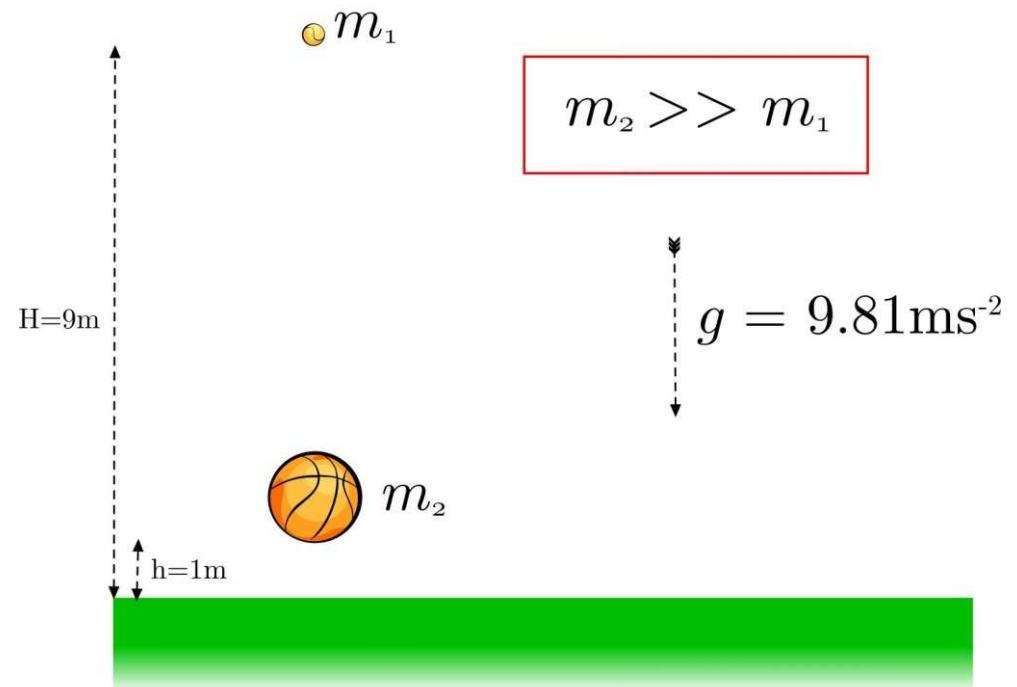
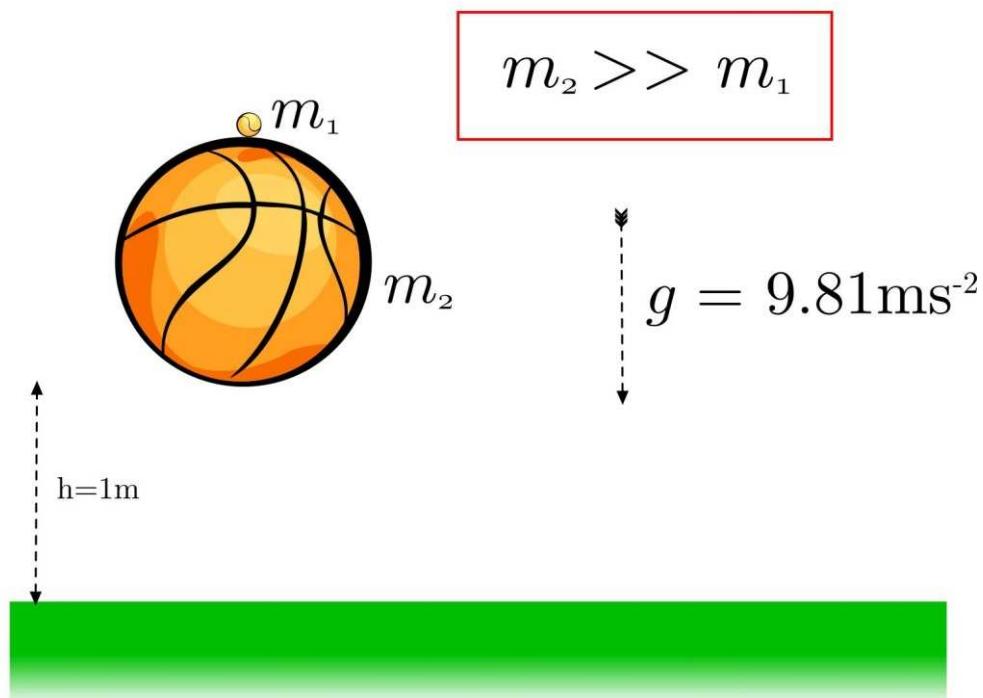
$$f(z) = \frac{ze^{iz}}{1+z^2} = \frac{ze^{iz}}{(z+i)(z-i)}$$

$$\oint_C f(z) dz = \lim_{R \rightarrow \infty} \left\{ \text{Contour} \right\}$$

### 13. velocity amplifying elastic collider

Balls are dropped from rest

Following collision, the smaller mass rises up to *nine times* the distance fallen!



$$v_1 = u \left( \frac{3 - m_1/m_2}{1 + m_1/m_2} \right)$$

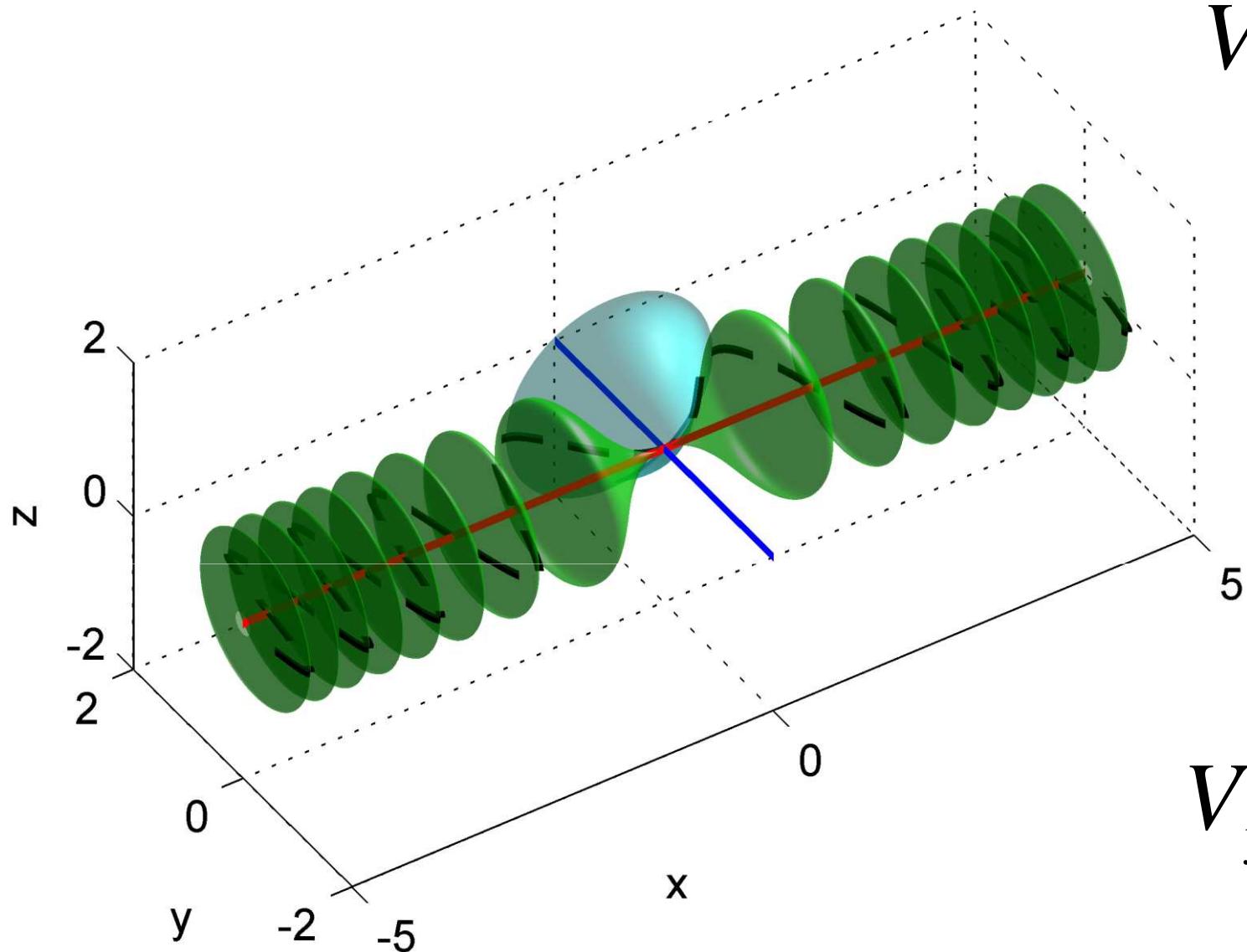
$$u^2 = 2gh$$

## 14. volumes of revolution

Volume of revolution about x and y axis of

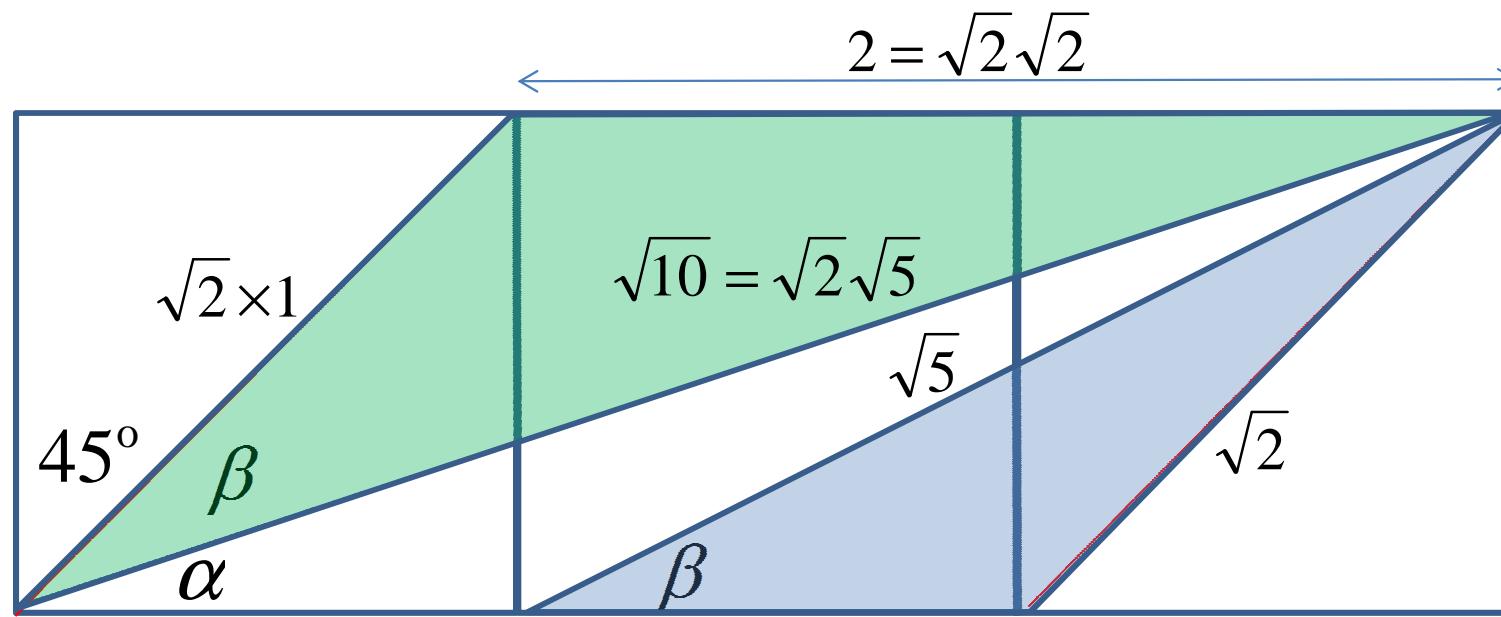
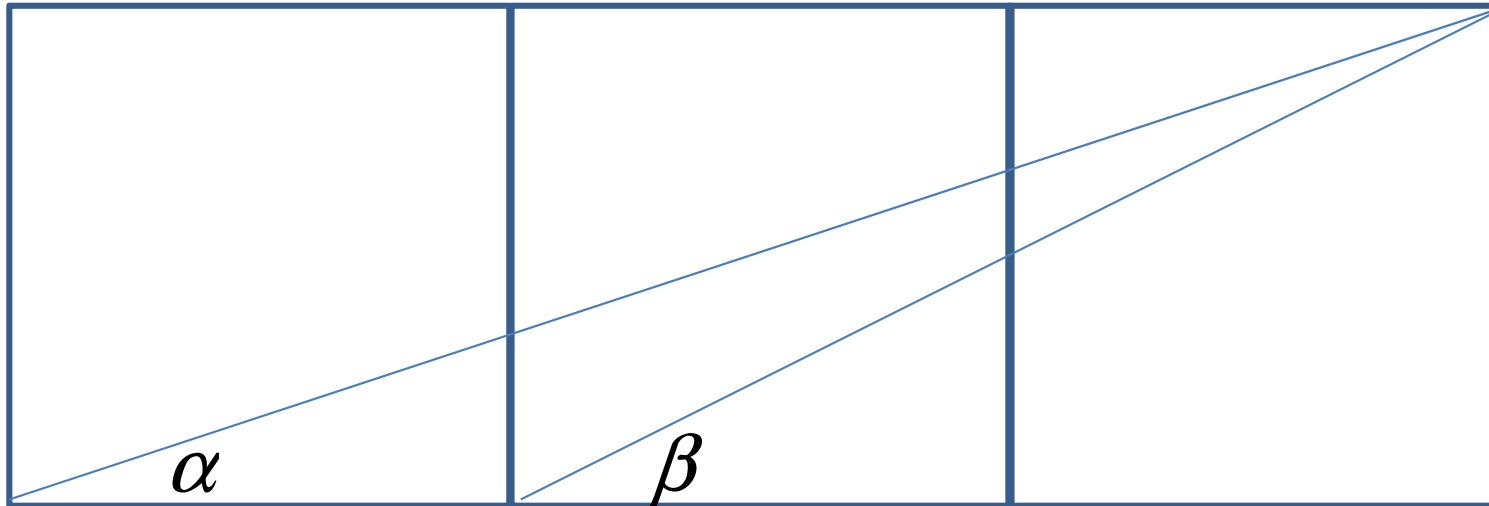
$$y = \sin(x^2)$$
$$\text{Vx} = 14.3304$$

$$V_x = \int_a^b \pi y^2 dx$$



$$V_y = \int_A^B \pi x^2 dy$$

15. Three squares 45 degree angle problem



$$\alpha + \beta = 45^\circ$$

1

Similar triangles!

Scale factor  $\sqrt{2}$



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# Have a marvellous summer!

