Primera Conferencia Científica de la RCAI

RCAI

Red de Científicos Argentinos en Italia

Bologna, Istituto IMM-CNR, 3 Diciembre 2016

Modelización de Sistemas Complejos

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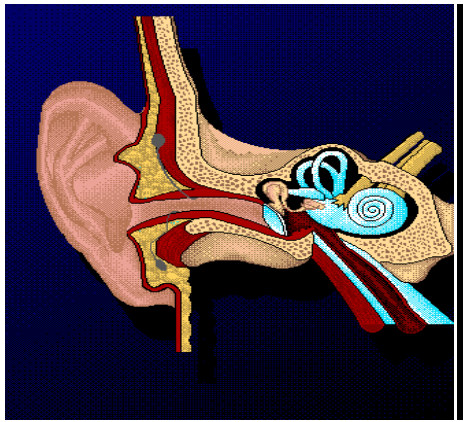
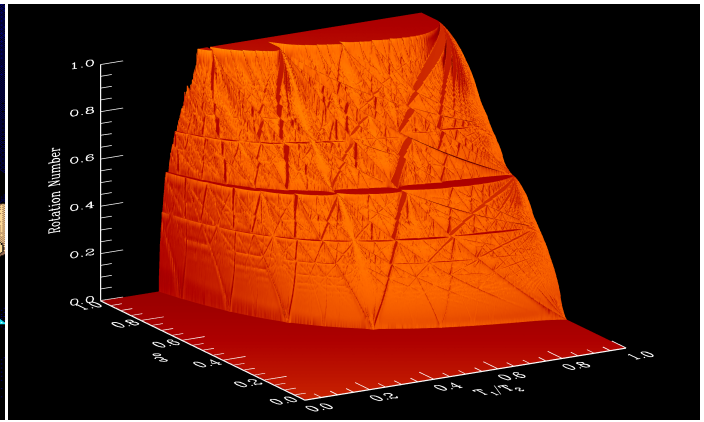
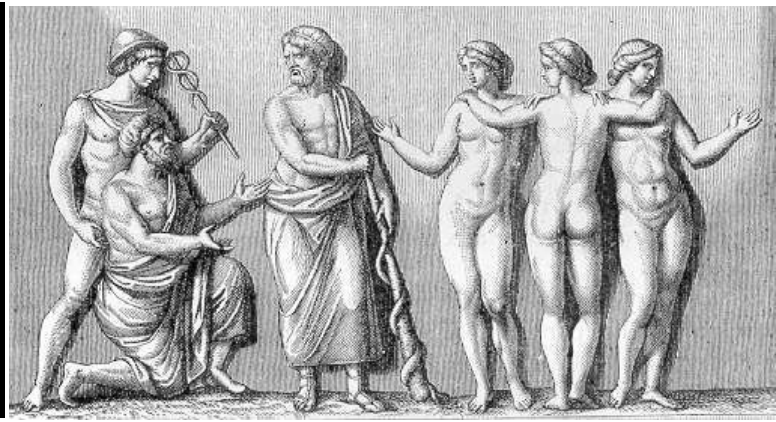
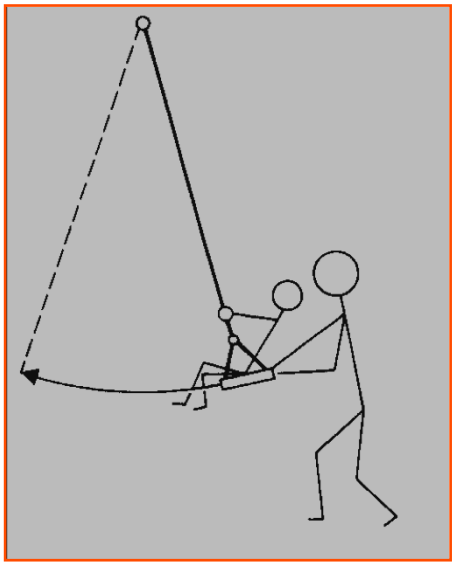




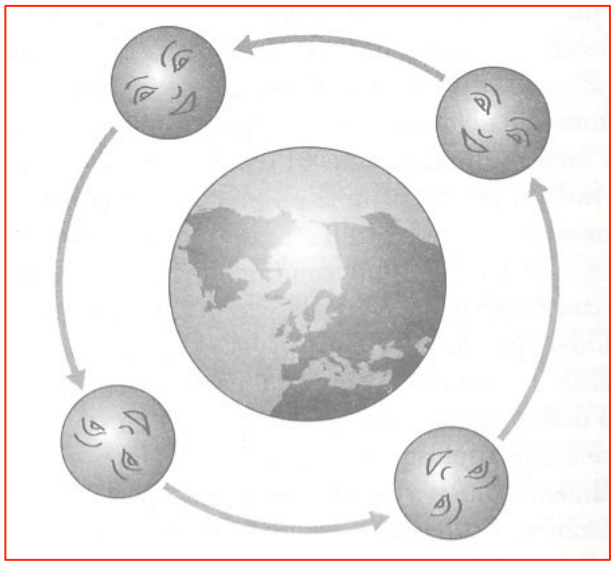


La Musica delle Sfere in Chiave Moderna

Il sistema dinamico più semplice
Pendolo semplice = altalena



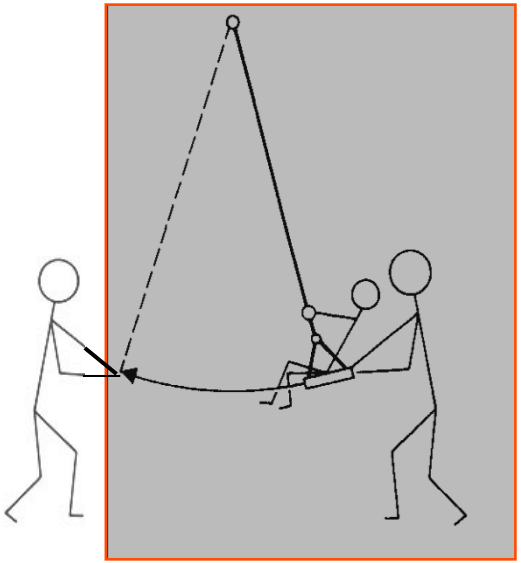
Sincronizzazione
Risonanza di due frequenze



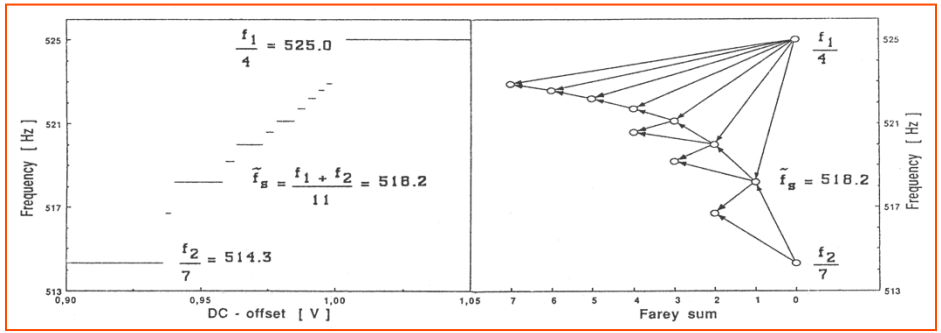
Esempio:
Canne d'organo

La Musica delle Sfere in Chiave Moderna II

Altalena forzata con due frequenze



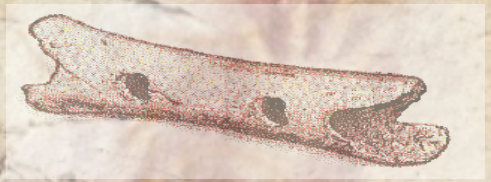
Risonanze di tre frequenze



1/1
1/2
2/3
3/5
5/8

Prima di Pitagoras

Uomo di Neanderthal



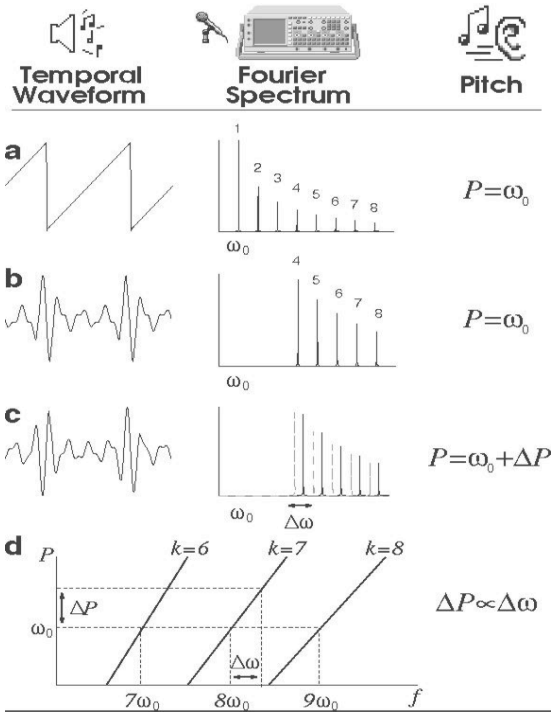
Flauto in osso
40.000-80.000 ac

Intervalli:
ottava 1/2
quinta 2/3

I cinesi

Flauti cinesi
7.000-9.000 ac
ottava 1/2
quinta 2/3

Pitch e la Fondamentale Assente

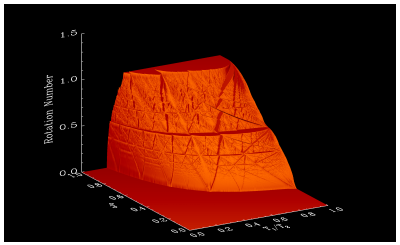


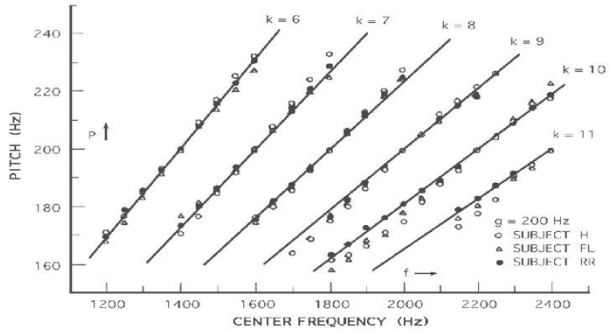
$$\frac{f_1 + f_2}{p + q}$$

Missing melody

Pure 200 Hz.

Triangular vs. Missing

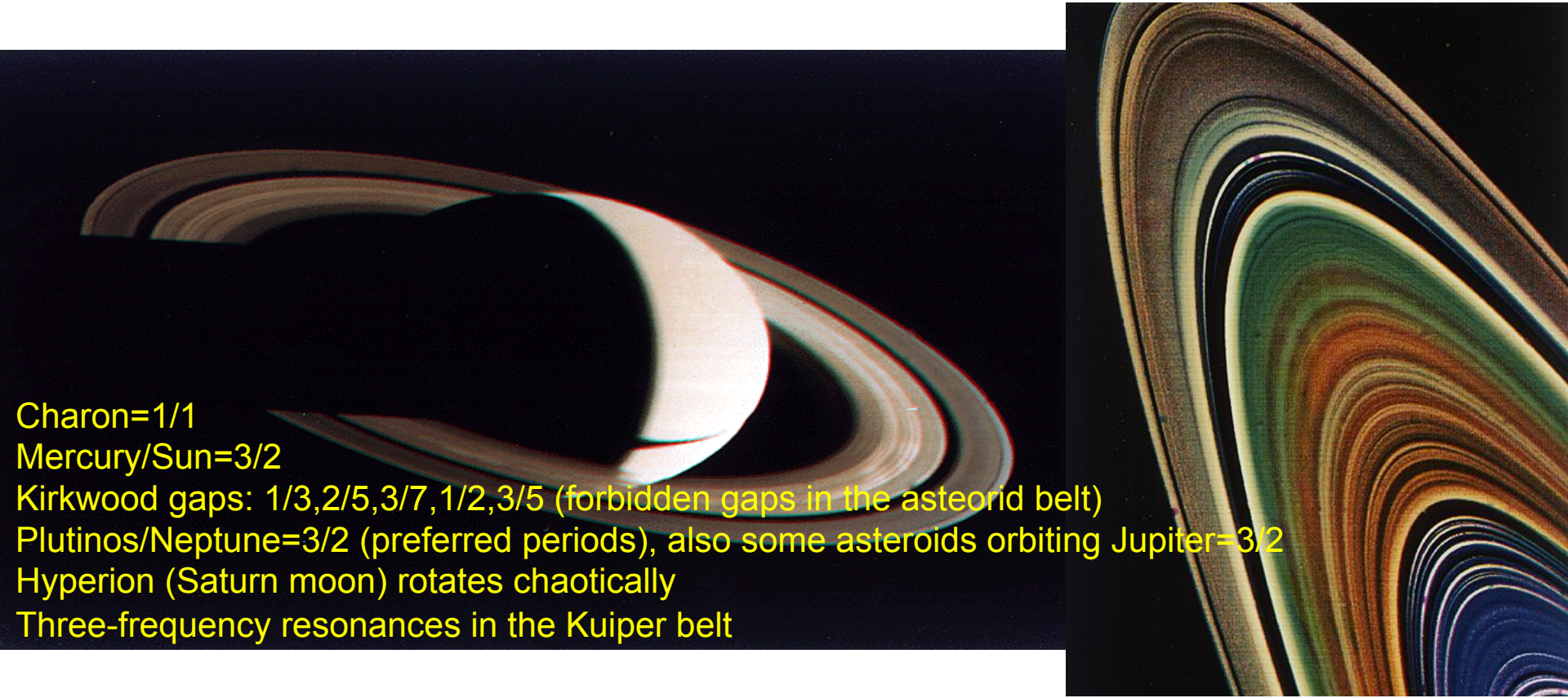




"Pitch perception: A dynamical-systems perspective" J. Cartwright, D.L. Gonzalez and O. Piro. *Proceedings of the National Academy of Sciences, PNAS, vol. 98, n.9, pp. 4855-4859 (2001).*

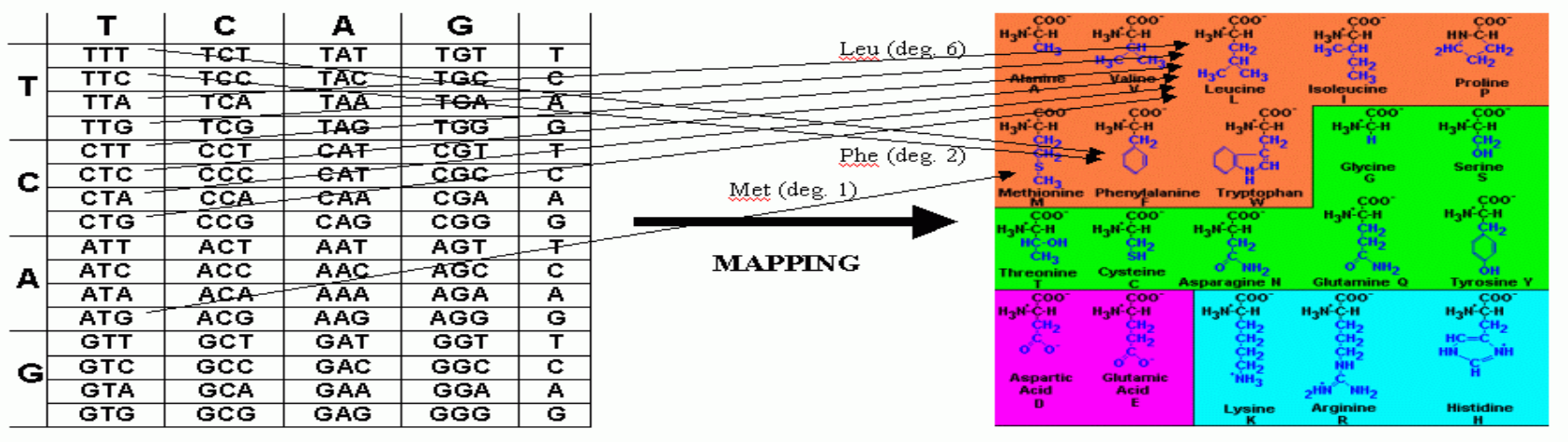
"Nonlinear dynamics of the perceived pitch of complex sounds" J. Cartwright, D.L. Gonzalez and O. Piro. *Physical Review Letters, vol. 82, n. 26, pp 5389-5392 (1999)*

Saturno: Gaps degli Anelli



Charon=1/1
Mercury/Sun=3/2
Kirkwood gaps: 1/3,2/5,3/7,1/2,3/5 (forbidden gaps in the asteorid belt)
Plutinos/Neptune=3/2 (preferred periods), also some asteroids orbiting Jupiter=3/2
Hyperion (Saturn moon) rotates chaotically
Three-frequency resonances in the Kuiper belt

The Genetic Code as a Mapping



64 codons; **4x4x4 = 64** (Words of three letters from an alphabet of four, i.e., A, T, C, G)

20 amino acids + Stop codon (Methyonine represents also the synthesis start signal)

→ **Redundancy and Degeneracy follow**

Mathematical model: integer number representation systems

Usual positional notation – power representation systems – base k

d_5	d_4	d_3	d_2	d_1	d_0
k^5	k^4	k^3	k^2	k^1	k^0

Digits: d_i (0, (k-1))

$$R_{(integer)} = d_5k^5 + d_4k^4 + d_3k^3 + d_2k^2 + d_1k^1 + d_0k^0$$

Univocity condition: $$(k-1)\sum_{n=0}^{m} k^n = k^{m+1} - 1$$

Example 1: k=10; decimal system

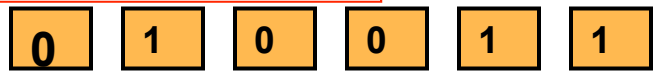
Digits: d_i (0, 9)

0	0	0	0	1	9
10^5	10^4	10^3	10^2	10^1	10^0

$$R = 1.10^1 + 9.10^0 = 19$$

Redundant representation systems

Example 2: Binary power system



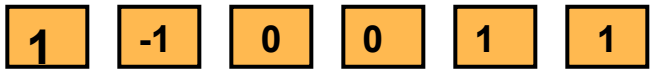
Digits: d_i (0, 1)

2^5 2^4 2^3 2^2 2^1 2^0

$$R = 0.2^5 + 1.2^4 + 0.2^3 + 0.2^2 + 1.2^1 + 1.2^0 = 19$$

Redundant Power Representations Using Out-of-Range Digits

Example 3: Binary signed digits with three possible values: **-1, 0, 1**



2^5 2^4 2^3 2^2 2^1 2^0

$$R = 1.2^5 + 0.2^4 - 1.2^3 + 0.2^2 + 1.2^1 - 1.2^0 = 19$$

Redundant

Non-power redundant representation systems

positional bases grow slowly than the powers of k

Example 4: k=2; Fibonacci system

1	1	1	1	0	1
8	5	3	2	1	1

Digits: d_i (0, 1)

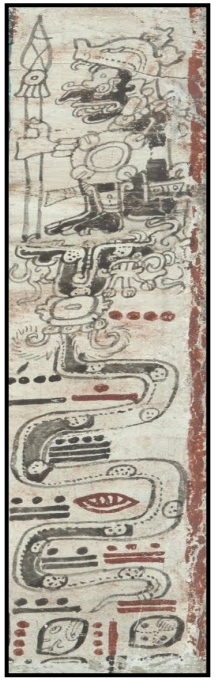
R = 1.8 + 1.5 + 1.3 + 1.2 + 0.1 + 1.1 = 19

Non-power representation systems are redundant, for example, the number 19 can be represented in the Fibonacci system in another alternative way:

1	1	1	1	1	0
8	5	3	2	1	1

R = 1.8 + 1.5 + 1.3 + 1.2 + 1.1 + 0.1 = 19

Maya serpent numbers



Non-power representation system 1,1,2,4,7,8

Represented number	Length 6 binary strings																											
	8	7	4	2	1	1		8	7	4	2	1	1		8	7	4	2	1	1		8	7	4	2	1	1
0	0	0	0	0	0	0																						
1	0	0	0	0	0	1		0	0	0	0	1	0															
2	0	0	0	0	1	1		0	0	0	1	0	0															
3	0	0	0	1	0	1		0	0	0	1	1	0															
4	0	0	1	0	0	0		0	0	0	1	1	1															
5	0	0	1	0	0	1		0	0	1	0	1	0															
6	0	0	1	1	0	0		0	0	1	0	1	1															
7	0	0	1	1	0	1		0	0	1	1	1	0		0	1	0	0	0	0								
8	0	1	0	0	0	1		0	1	0	0	1	0		1	0	0	0	0	0		0	0	1	1	1	1
9	1	0	0	0	0	1		1	0	0	0	1	0		0	1	0	1	0	0		0	1	0	0	1	1
10	0	1	0	1	0	1		0	1	0	1	1	0		1	0	0	1	0	0		1	0	0	0	1	1
11	1	0	0	1	0	1		1	0	0	1	1	0		0	1	1	0	0	0		0	1	0	1	1	1
12	0	1	1	0	0	1		0	1	1	0	1	0		1	0	1	0	0	0		1	0	0	1	1	1
13	1	0	1	0	0	1		1	0	1	0	1	0		0	1	1	1	0	0		0	1	1	0	1	1
14	0	1	1	1	0	1		0	1	1	1	1	0		1	0	1	1	0	0		1	0	1	0	1	1
15	1	0	1	1	0	1		1	0	1	1	1	0		1	1	0	0	0	0		0	1	1	1	1	1
16	1	1	0	0	0	1		1	1	0	0	1	0		1	0	1	1	1	1								
17	1	1	0	0	1	1		1	1	0	1	0	0															
18	1	1	0	1	0	1		1	1	0	1	1	0															
19	1	1	1	0	1	1		1	1	0	1	1	1															
20	1	1	1	0	0	1		1	1	1	0	1	0															
21	1	1	1	1	0	0		1	1	1	0	1	1															
22	1	1	1	1	0	1		1	1	1	1	1	0															
23	1	1	1	1	1	1																						

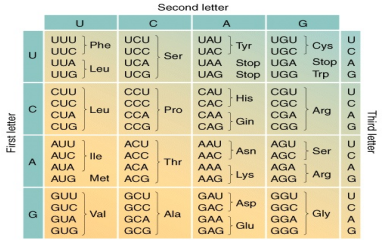
Degeneracy distribution Non-power representation system 1,1,2,4,7,8	
# of integer numbers	Degeneracy
2	1
12	2
2	3
8	4

Unique solution 1,1,2,4,7,8

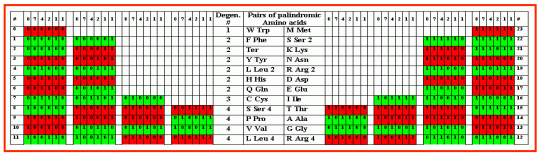
Degeneracy distribution Euplotes nuclear genetic code	
# of amino acids	Degeneracy
2	1
12	2
2	3
8	4

From a structural isomorphism to a true model

GENETIC CODE



NON-POWER REPRESENTATION



64 Codons → 24 (aa + signs)

64 Binary strings → 24 Integer numbers

SYMMETRY

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