Transdisciplinarity: Hidden connections between various fields of knowledge

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Organization

- Unity of Knowledge- The need due to complex current problems
- Unity of Knowledge- The Hope-Unity in human thinking
- Unification of fragmented knowledge in different worlds- One of the missions of Systems Science
- Transdisciplinarity- discovering hidden connections between and establishing a common platform for people from diverse disciplines
- An example: Philosophy-Mathematics-Genetics for a holistic understanding of a class of mathematical forms
- A genetic molecular model for mathematical concepts
- Generations of concepts
- A general perspective of the evolution
- Discussion and conclusion

Unity of Knowledge- The need

- Complex current problems that require the support of knowledge from diverse disciplines
- One of the CHALLENGING problems is that of SUSTAINABLE DEVELOPMENT

SUSTAINABLE DEVELOPMENT

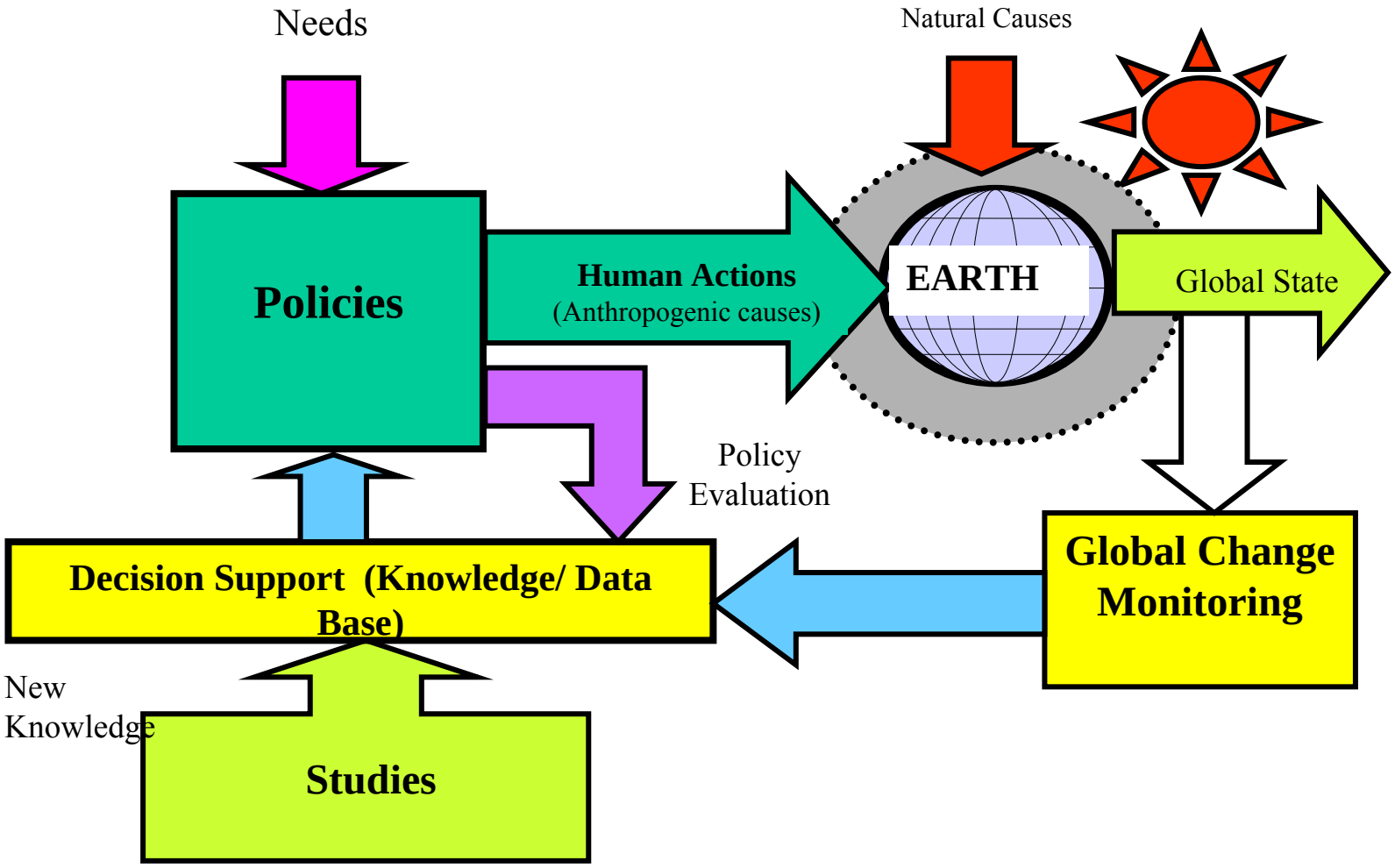
- is "*development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs*."

-Brundtland Commission (1987)

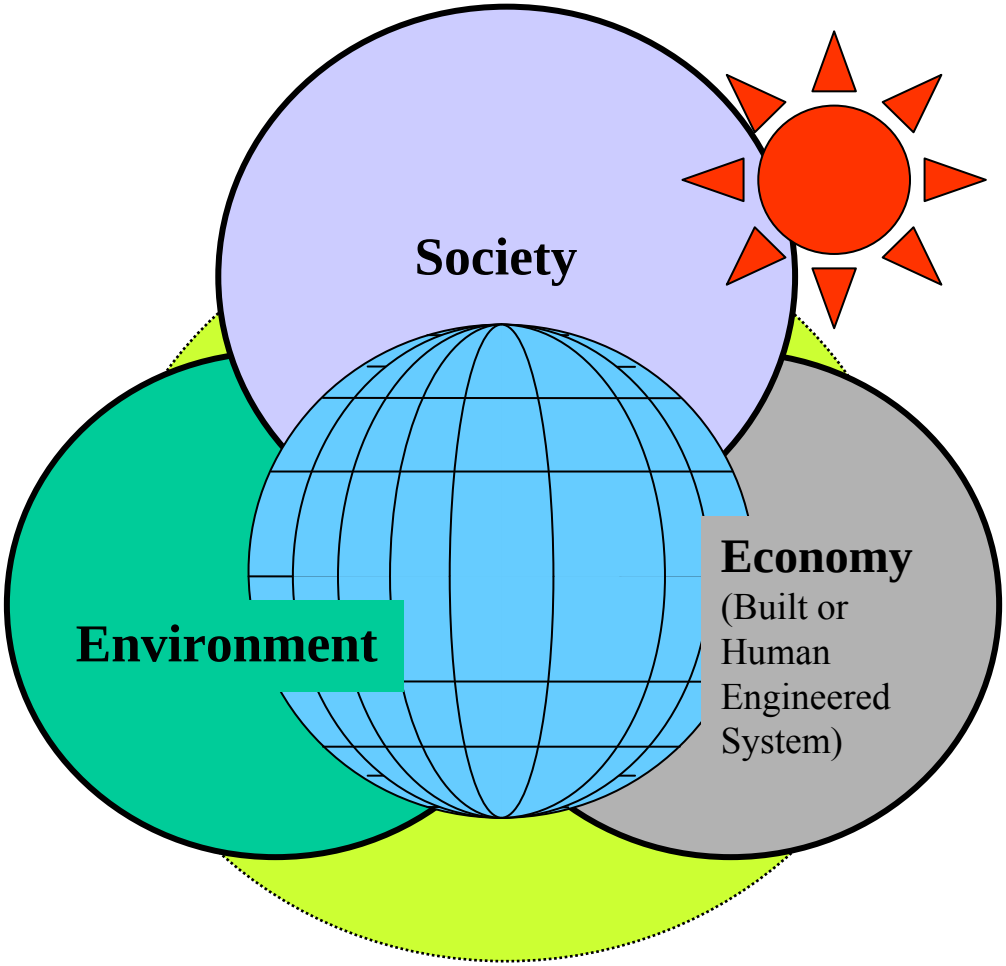
Agenda-21 (Earth Summit Rio, 1992): A document to guide human actions for Sustainable Development in the 21st Century

A great challenge in this context for Systems Science and Engineering:

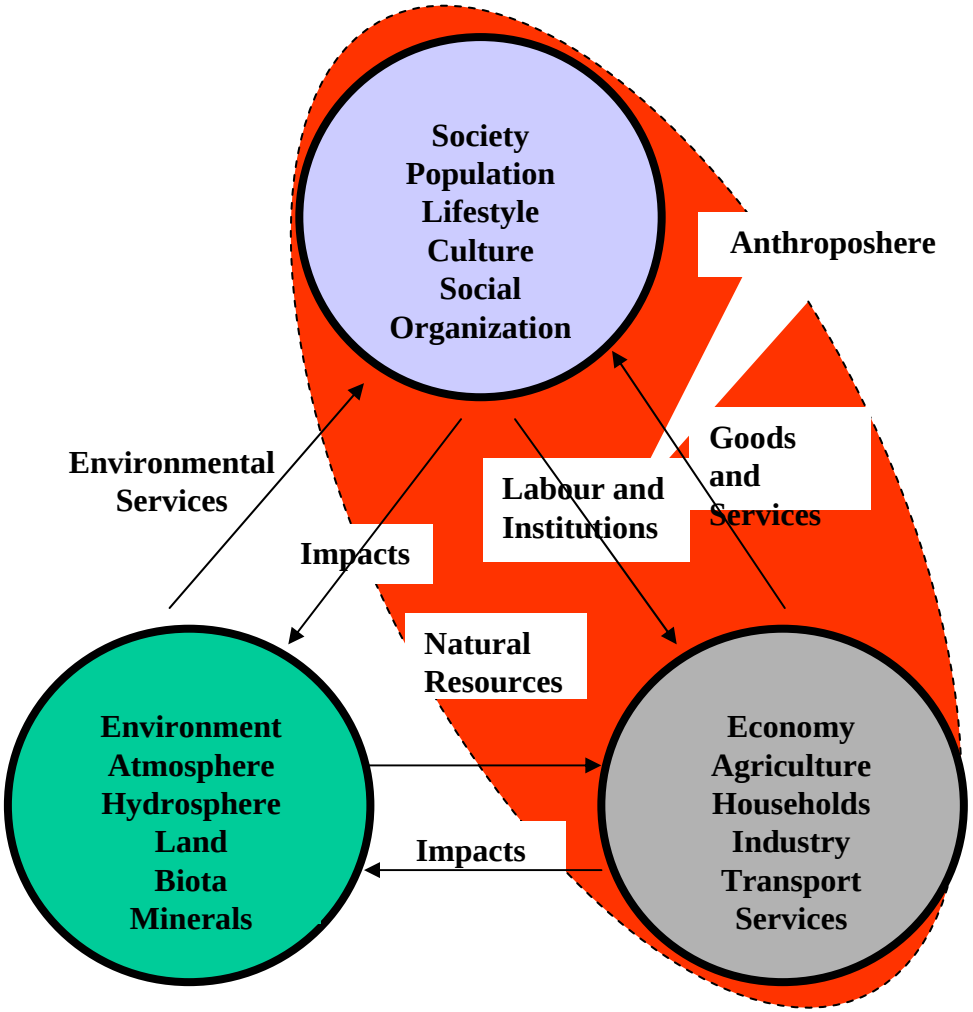
“THE GRAND DYNAMIC SYSTEM”



THE GRAND DYNAMIC SYSTEM
"THE EARTH SYSTEM"



MAJOR SUBSYSTEMS OF OUR GRAND SYSTEM



Complex interactions among the various subsystems

UNITY OF KNOWLEDGE - CHALLENGES

Diversity of

- ‘WORLDS’
- DISCIPLINES
- ENTITIES
- CONCEPTS
- PERSPECTIVES
- ‘LANGUAGES’
- levels of ‘COMPLEXITY’, ‘QUANTIFIABILITIY’, ‘UNCERTAINTY’, ‘VAGUENESS’, etc.

UNITY OF KNOWLEDGE – THE BASIS FOR MAJOR HOPE

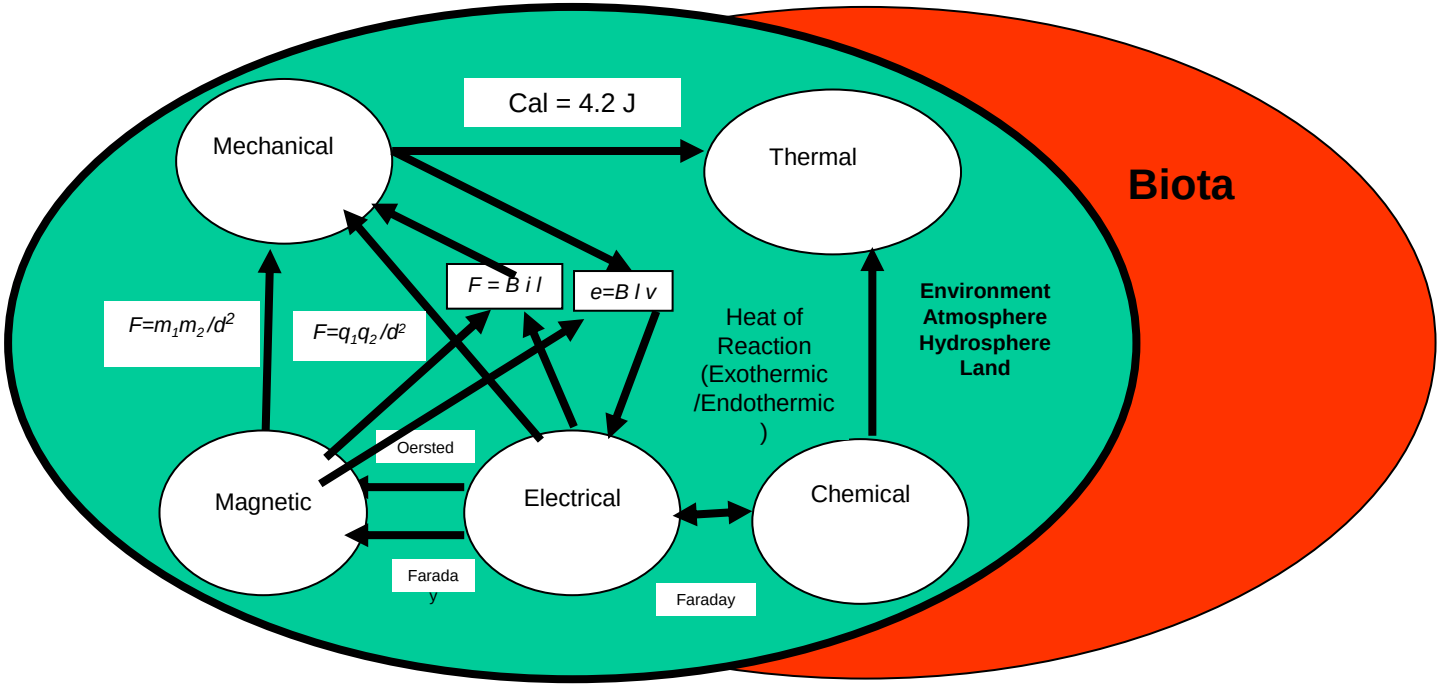
All disciplines are products of the HUMAN KNOWLEDGE INDUSTRY

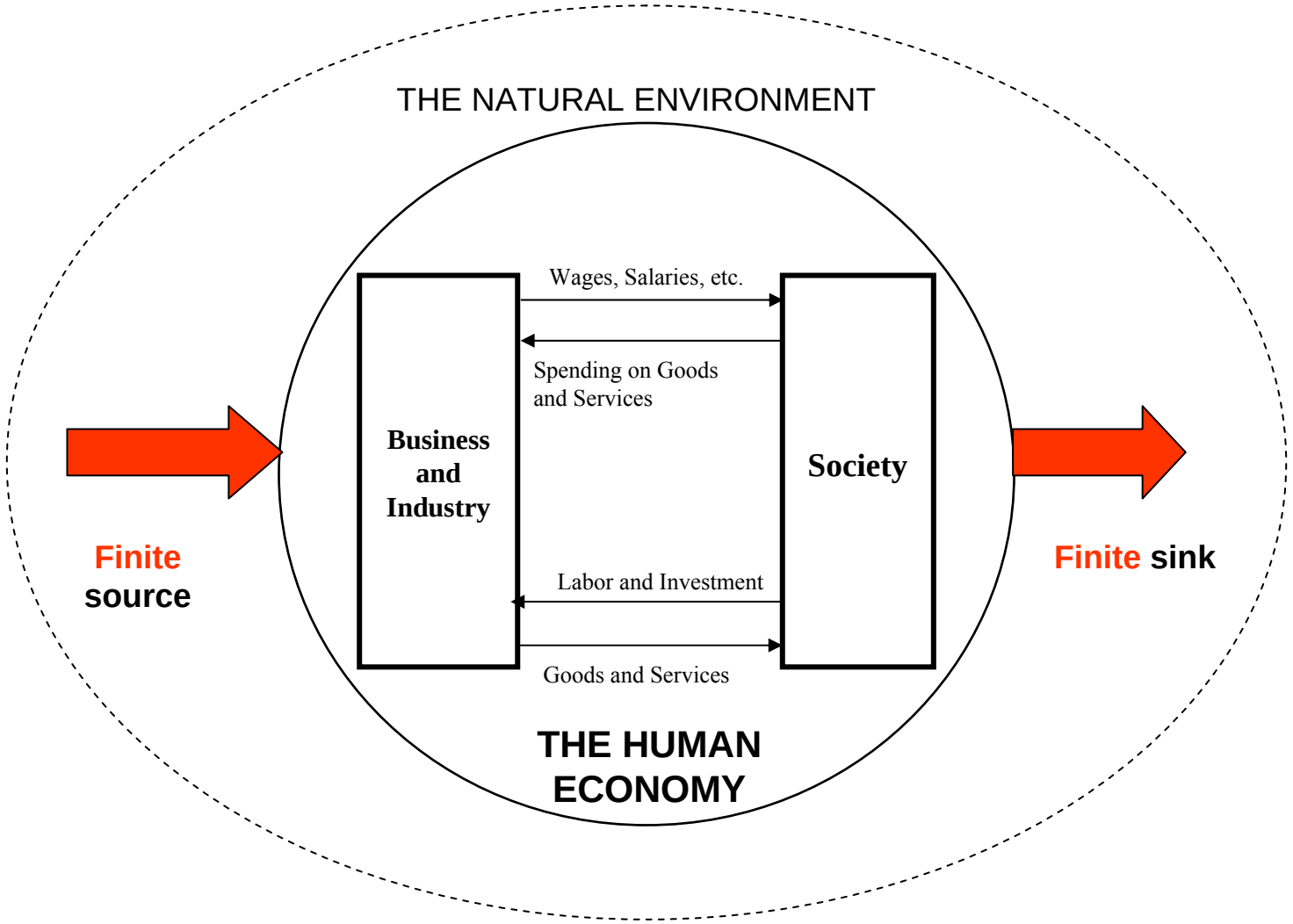
GENETICALLY
the same type of PLANT –
THE HUMAN MIND

HISTORY OF UNIFICATION OF KNOWLEDGE

- DISCOVERY OF HIDDEN CONNECTIONS BETWEEN DIFFERENT WORLDS – BEGAN ONLY A FEW HUNDRED YEARS AGO IN PARTS OF THE ‘ABIOTIC’ NATURAL SYSTEM

HIDDEN CONNECTIONS IN THE ‘ABIOTIC’ WORLDS





The connection between HUMAN ECONOMY and THE NATURAL ENVIRONMENT

TRANSDISCIPLINARY PATHWAYS across DIVERSE DISCIPLINES

A case study

‘MATHEMATICS-PHILOSPOPHY-GENETICS’

- To appreciate the role of certain philosophical concepts in laying the foundations for mathematics
- To identify an evolutionary pattern in the development of a species of mathematical concepts
- To visualize the ‘GENETIC’ structure behind the evolution (FOUR base units)
- To demonstrate the evolution of a species mathematical concepts by ‘MUTATION’ of the ‘FOUR’ base units.
- The common traits of the species of mathematical

THE NUMBER CONCEPT

- **The Babylonians- position value concept**
- **Early limitations**

The key concepts seemingly inspired by the HINDUS through their spiritual philosophy

The Key Concepts
ZERO (& INFINITY)

- The Hindu (not religious but geographical– related to the region around and beyond the *Indus* /*Sindhu* / Hindu river) intellect and spiritual philosophy
- The concept of GOD and its possible influence on the creation of ZERO-INFINITY concepts

Brahma Gñaanam

(Understanding The Supreme)

Prayers addressed to The Supreme in 'Srimahabhagavatham' (Chapter 8, Section 3) by the renowned Telugu poet *Bammera Potana*, reflect these concepts

73

By whom the universe is created;
Within whom it remains absorbed;
The Supreme Lord,
Who is the Root Cause;
Who is devoid of origin, middle and end;
Who happens to be everything;
In such a One, the Self-Created; I seek refuge.

74

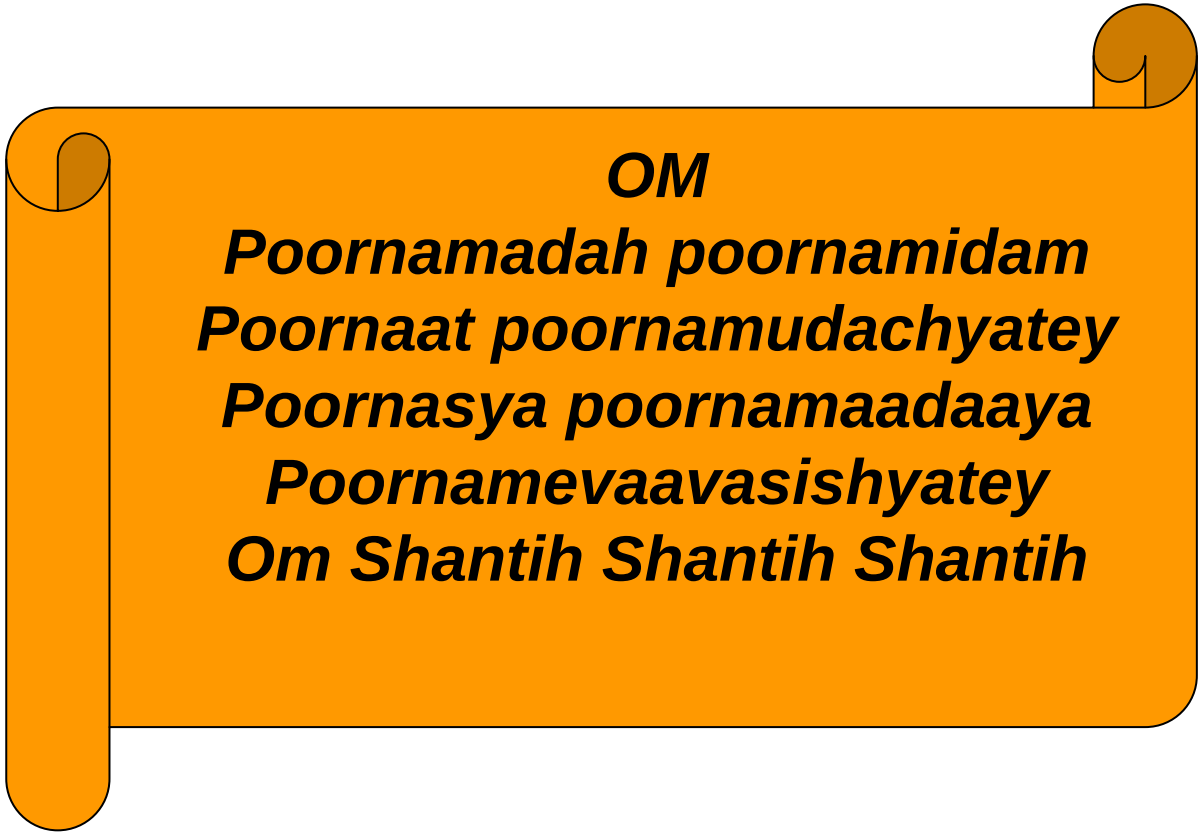
I think of the One
That is the universe both exclusive and inclusive of Himself,
The eternal witness to all events, The Spotless and The Untarnished,
The Self-created.

83

….The Supreme Lord,
The First, The Ineffable,
The Goal of spiritual pursuits,
The Complete One,
The Supreme Soul,
The Brahma, The Other One,
The physical sense defying,
The Largest and The Smallest - I propitiate.

85

The Lord who is without gender,
Without any physical form,
Not (physically) evidenced by actions properties, differences and places
And yet in the background happens to be all these - I think of Him.



- *That (The Supreme Being) is FULL, This (Universe) is FULL*
- *FULLNESS arises out of FULLNESS*
- *When the FULLNESS from The FULL is taken away FULLNESS only remains* **(f – f = f)**

$$f - f = f \quad (!)$$

- A property possessed only by **zero** and **infinity**
- Two non-physical (supernatural!) entities
- Devoid of sign and immeasurable
- Inseparably tied to each other

Synonyms for ZERO

- ***Aakaasham***
- ***Gaganam***
- ***Shuunyam***
- ***Antariksham***
- ***Marutpatham***

- **Source: *'Saankhya Nighantu' in 'Muhurtha Darpanam'***
- ***Nighantu*: A book of synonyms (Dictionary)**
- ***Muhurtha Darpanam*: Mirror of Moments (of time)**

TWELVE written by different peoples

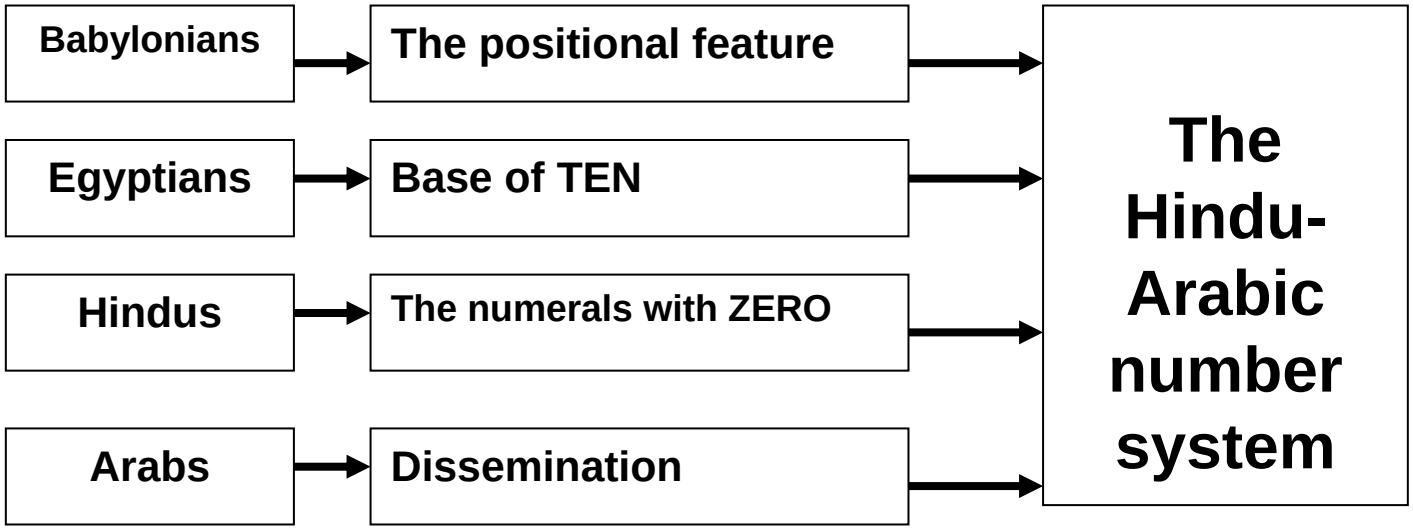
People	Expression
Babylonians	
Romans	**XII**
Egyptians	**∩II**
Mayans	
Greeks(Attic)	**ΔII**
Greeks(Ionian)	**iβ**
Hindus	**12**

Evolution of the pattern

Babylonians

- **Positional feature**
- **Basis TEN and SIXTY mixed**
- **Multiples of SIXTY and ONE-SIXTIETH appear in the same way as UNITS**
- **SIXTY is still used in astronomy / geometry (angle) , and time**

The decimal system



Md. Ibn-Musa Al Khowarizmi's famous manual translated into Latin in the 12th Century

The symbols were standardized in the 16th Century

Number System Features

Symbols: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9

Base (Radix): TEN

Positional rule: Power law

Representation pattern

Position value	**…**	**r^{2}**	**r^{1}**	**r^{0}**	**r^{-1}**	**r^{-2}**	**…**
Location Address	**…**	**2**	**1**	**0**	**-1**	**-2**	**…**
Spatial pattern of symbols	**…**	**d_{2}**	**d_{1}**	**d_{0}**	**d_{-1}**	**d_{-2}**	**…**

r = TEN

A number N: Inherently zero-dimensional

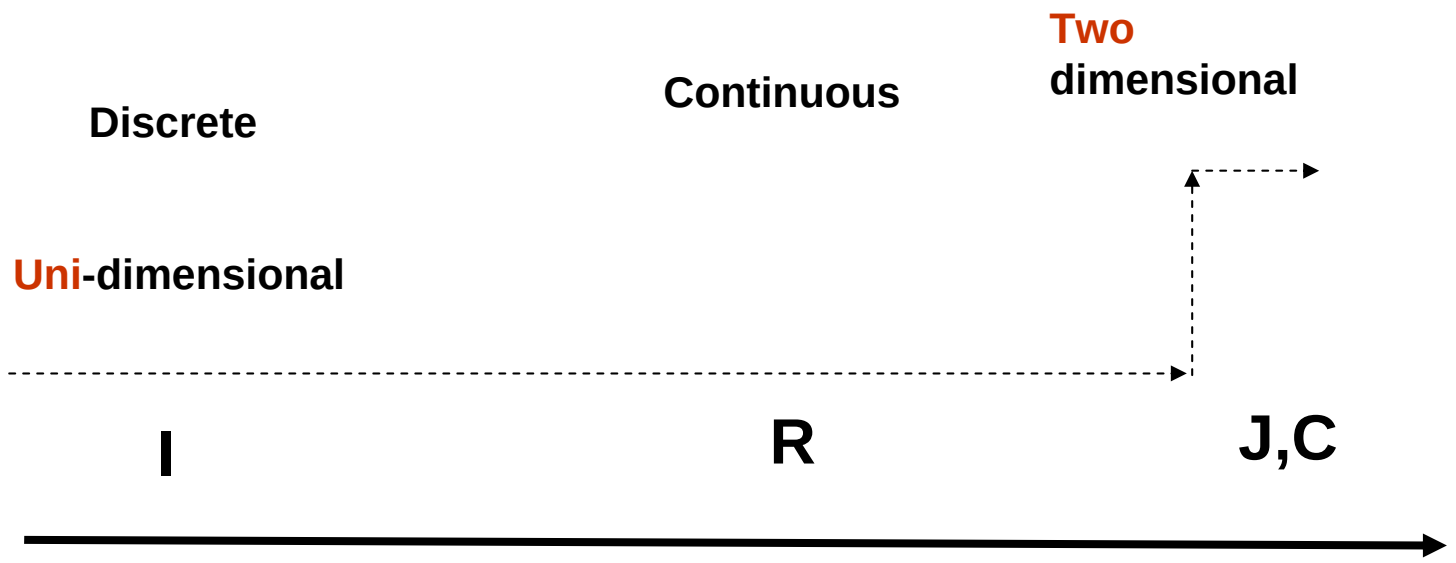
Representation renders it one-dimensional

$$N = \sum_{k=-\infty}^{k=\infty} d_k r^k$$

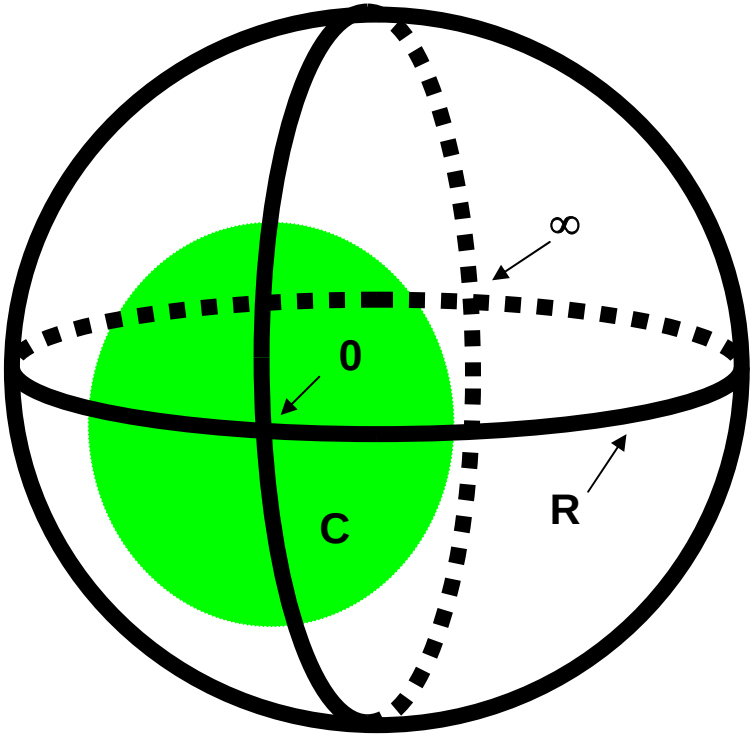
Various ancient systems of denoting numbers

Babylonian	**Y**	**YY**	**YYY**	**YYYY**	**YYYYY**	**YYYYYY**	**YYYYYYY**	**YYYYYYYY**	**YYYYYYYYY**	**<**	
Egyptian	**I**	**II**	**III**	**IIII**	**IIIII**	**IIIIII**	**IIIIIII**	**IIIIIIII**	**IIIIIIIII**	𓎆	
Greek	**A**	**B**	**Γ**	**Δ**	**E**	**F**	**Z**	**H**	**θ**	**I**	
Roman	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	
Ancient Chinese	一	二	三	四	五	六	七	八	九	十	
Mayan	**.**	**..**	**...**	**....**	**—**	**. —**	**.. —**	**... —**	**.... —**	**— —**	ᑐ
Hindu	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**0**

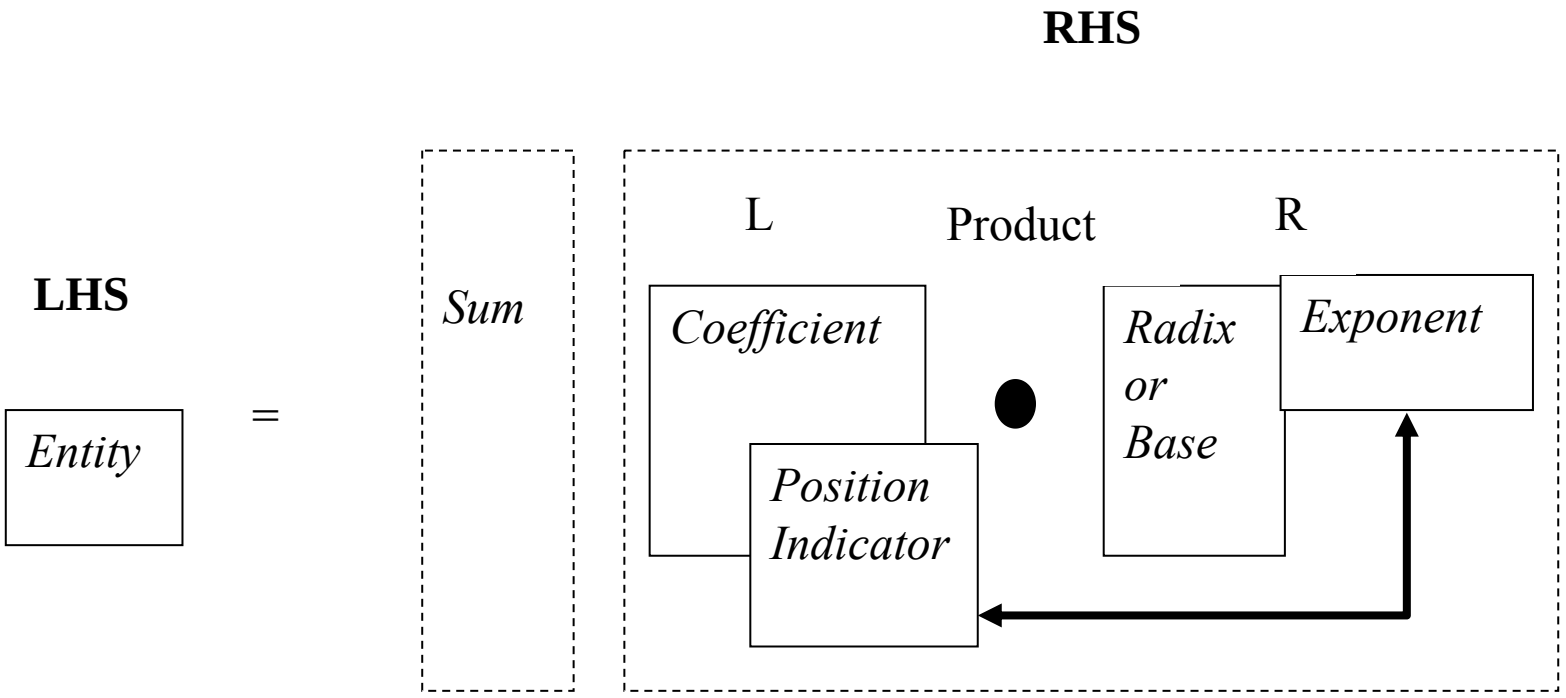
Development of
The course of evolution of the number concept (the subunits I,R,J,C)



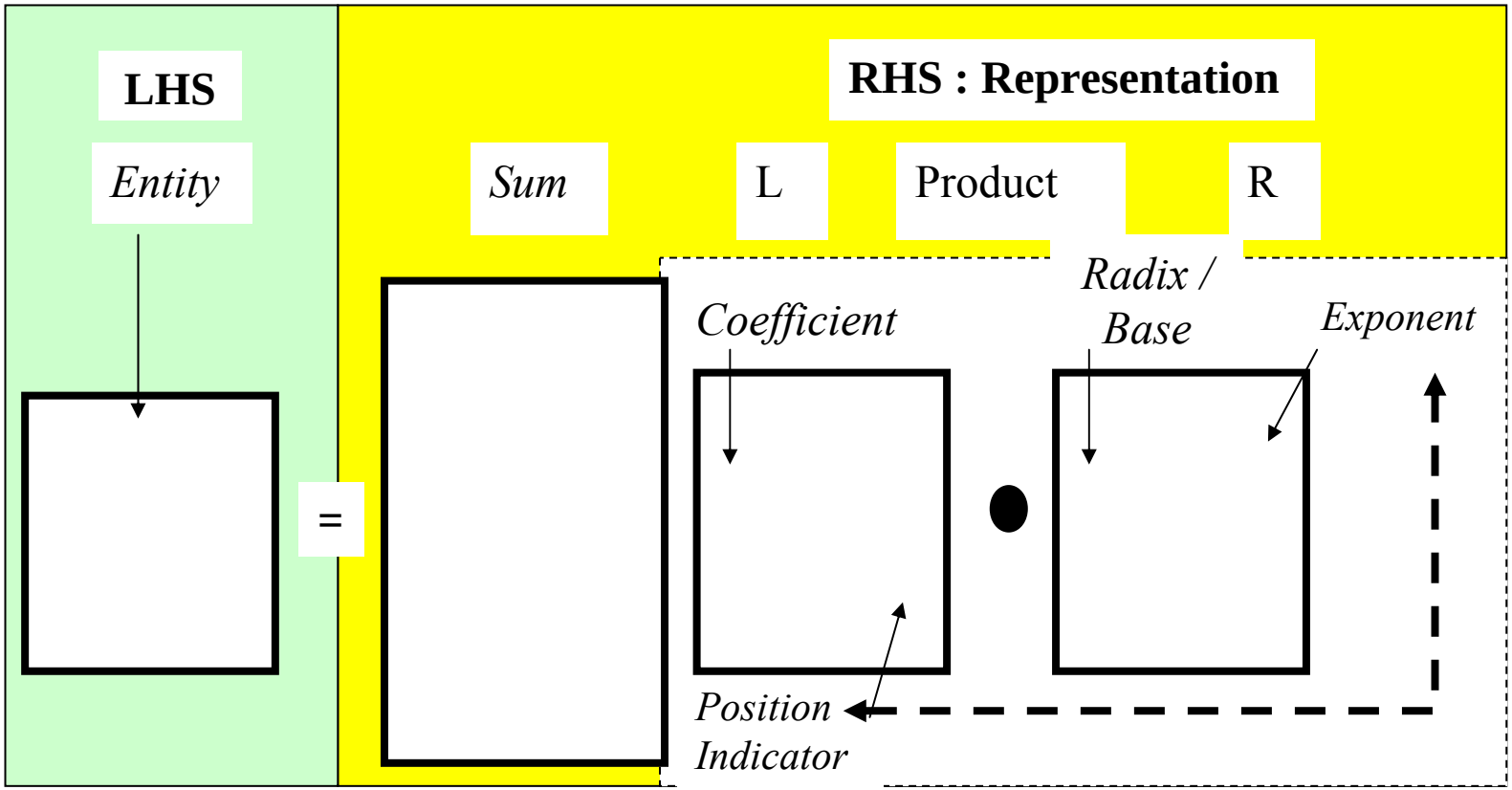
The number space



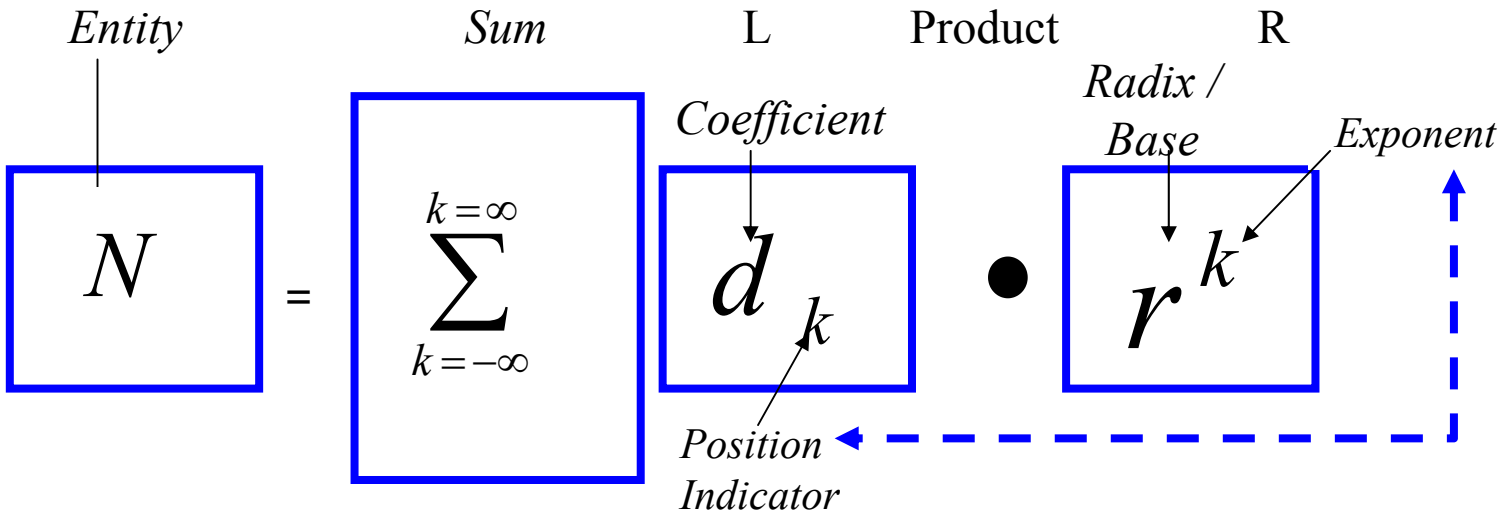
The generic SOP structure of the number system



Template (The structure of the molecule)



Number Systems



$$d_k = \left\lfloor \frac{N}{r^k} \right\rfloor - \left\lfloor \frac{N}{r^{k+1}} \right\rfloor r$$

Radix : r: +ve integer ≥ 2

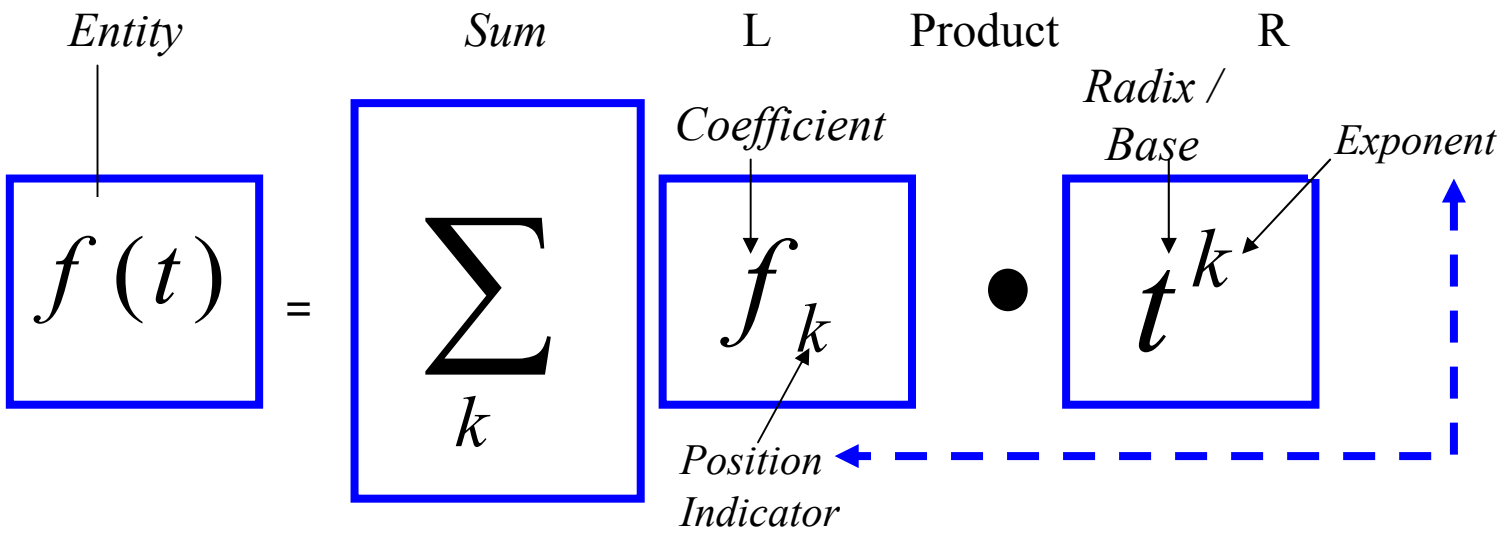
Coefficient : $0 \leq d_k \leq r\text{-}1$

Position index: k: Real integer

Position value: r^k

Remarks: Power law

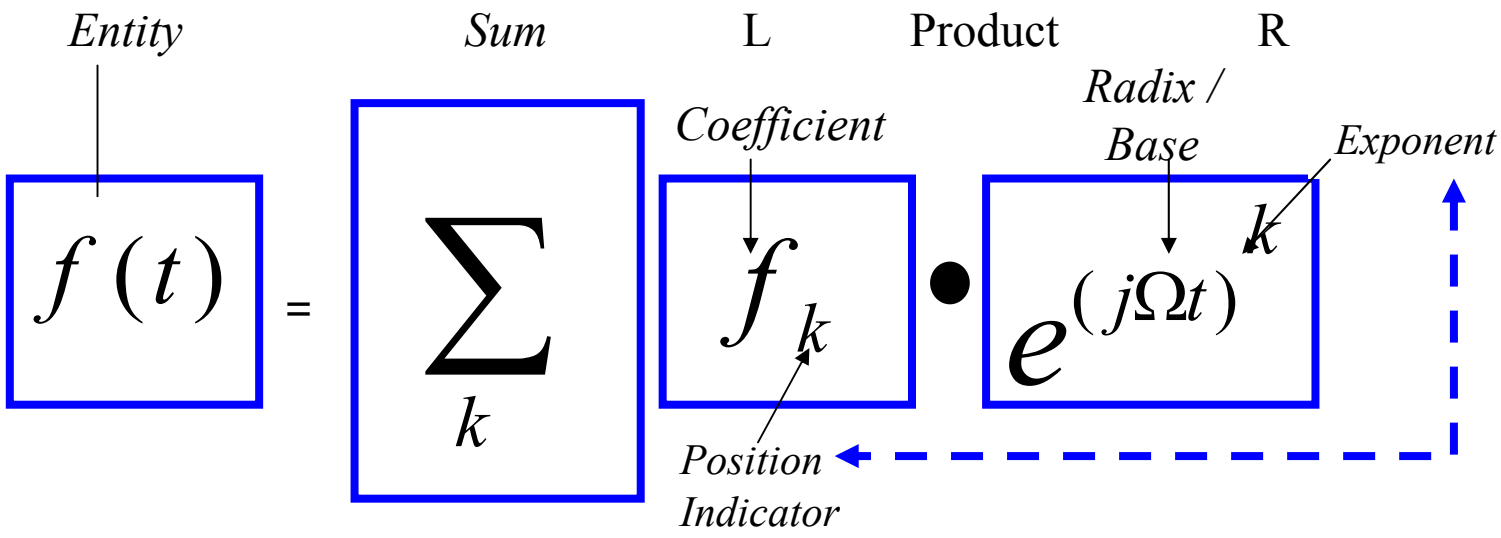
Function as Power Series



$$f_k = \frac{1}{k!} \frac{d^k}{dt^k} f(t)$$

Radix :	Real, t
Coefficient :	Real, f_k
Position index:	k: Real integer
Position value:	t^k
Remarks:	Power law

Discrete Fourier Series of a Periodic Function



$$f_k = \frac{\Omega}{2\pi} \int_{-\pi/\Omega}^{\pi/\Omega} f(t) e^{-jk\Omega t} dt$$

Radix : $e^{j\Omega t}$

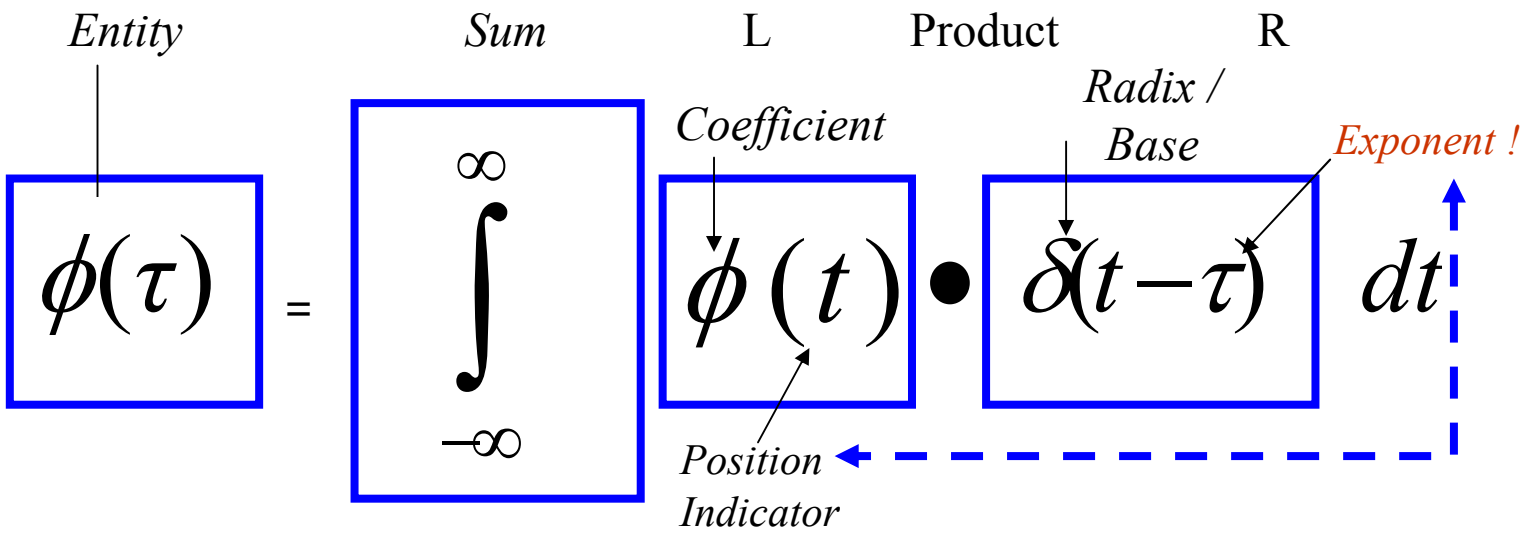
Coefficient : Discrete spectrum, f_k

Position index: k: Real integer

Position value: $e^{(j\Omega t)^k}$

Remarks: Power law

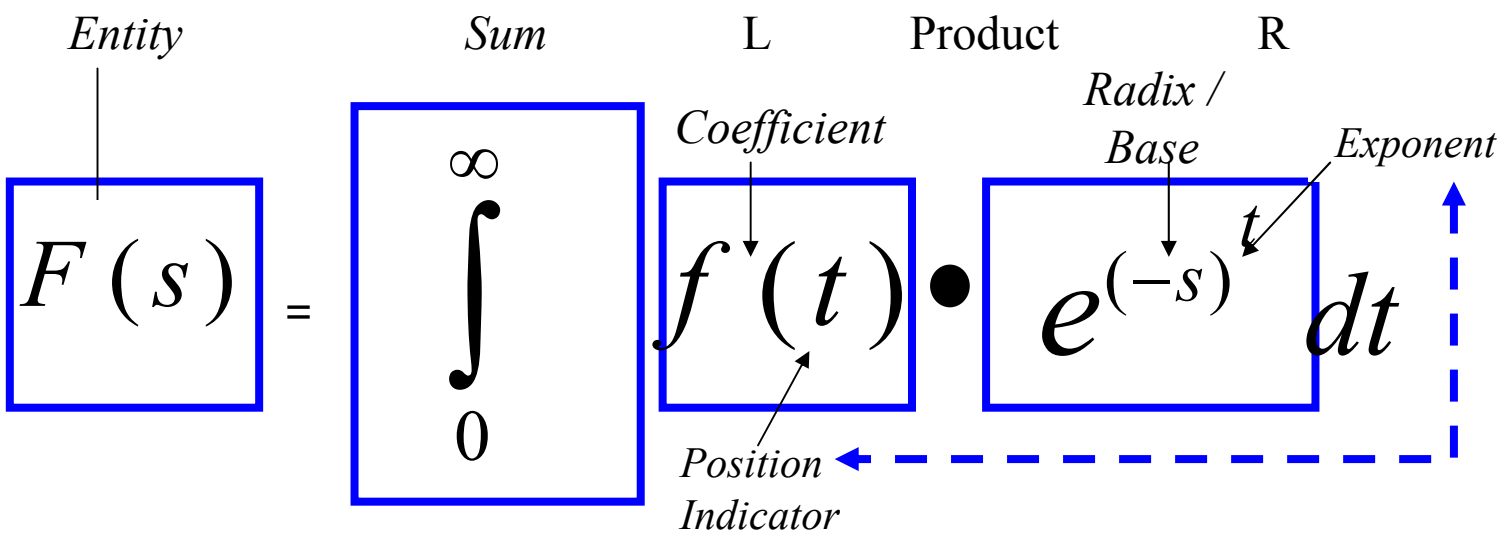
Generalized Functions



$\phi(t) = \text{Generalized Function}$

Radix : Dirac delta function $\delta(t)$
Coefficient : Generalized function
Position index: τ: Real
Position value: Shifted delta function
Remarks: Natural positioning

Laplace Transform



$$f(t)=\frac{1}{2\pi \mathrm{j}}\oint F(s)(e^{t})^{s}\,ds$$

Radix : Complex variable e^{-s}

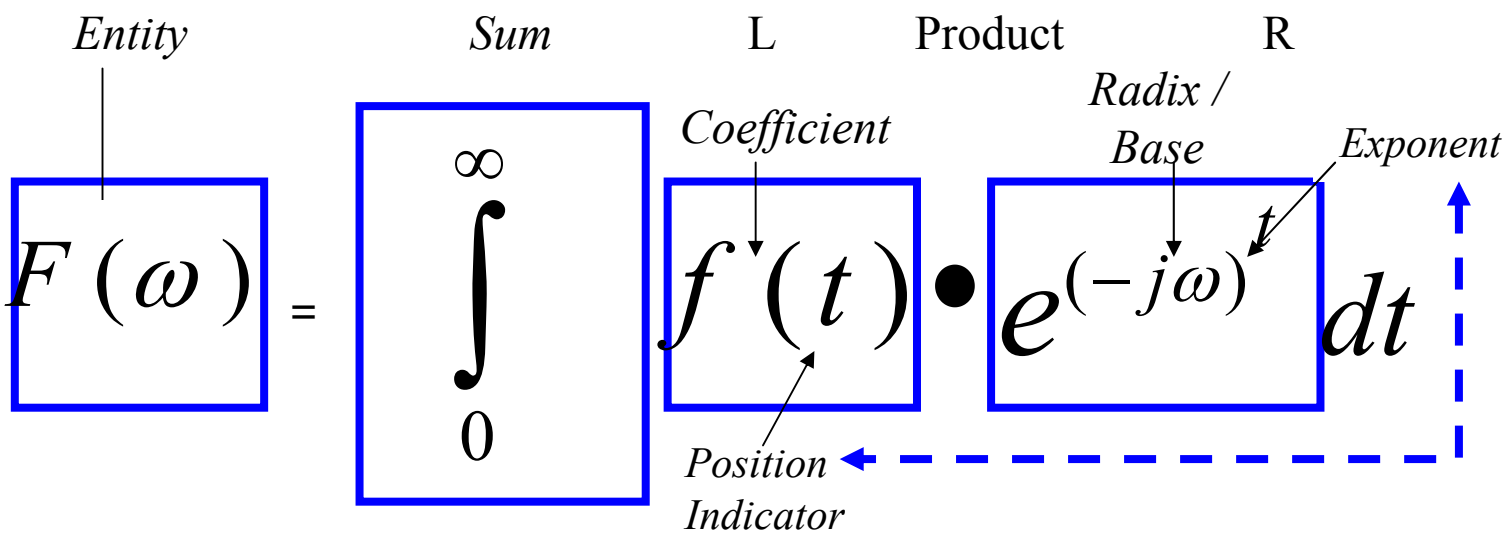
Coefficient : Real $f(t)$

Position index: Real $t \in [0, \infty]$

Position value: $e^{(-s)^t}$

Remarks: In general $\alpha^{(-s)}$

Fourier Transform



$$f(t) = \frac{1}{2\pi} \oint F(\omega)(e^{j\omega t}) d\omega$$

Radix : Complex variable $e^{j\omega}$

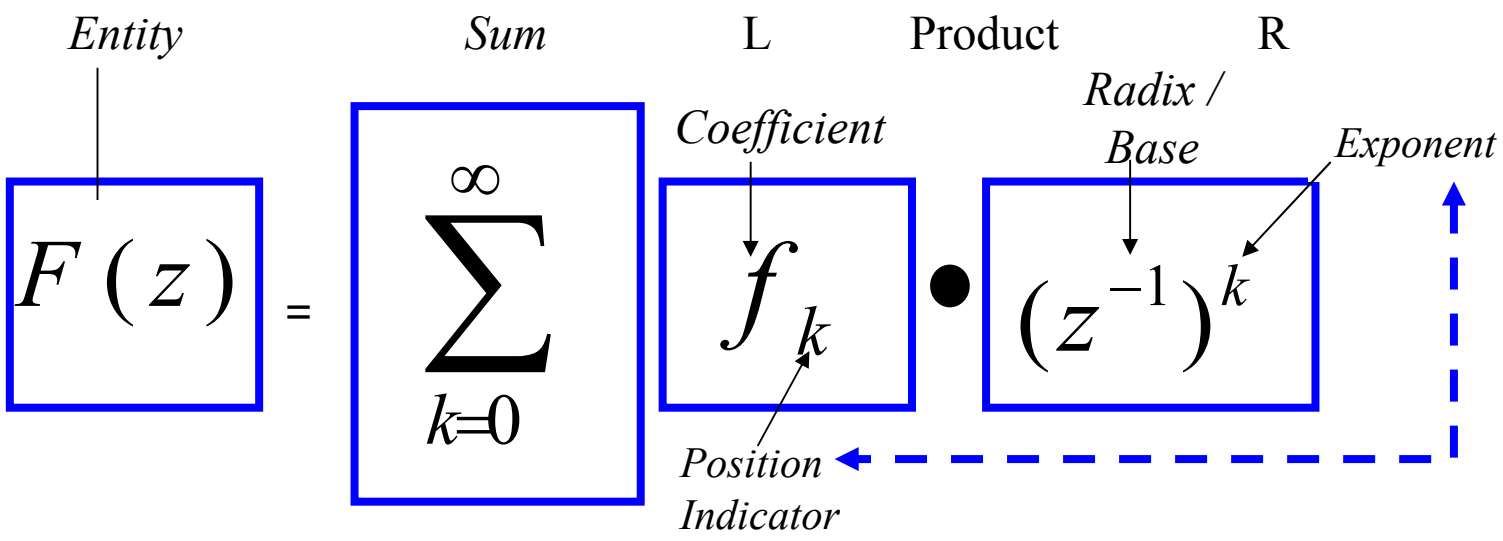
Coefficient : Real $f(t)$

Position index: Real $t \in [0, \infty]$

Position value: $e^{(-j\omega)t}$

Remarks: Continuous spectrum

z-Transform



$$f_k = \frac{1}{2\pi \mathrm{j}} \oint F(z) z^{k-1}$$

Radix : Complex variable z^{-1}

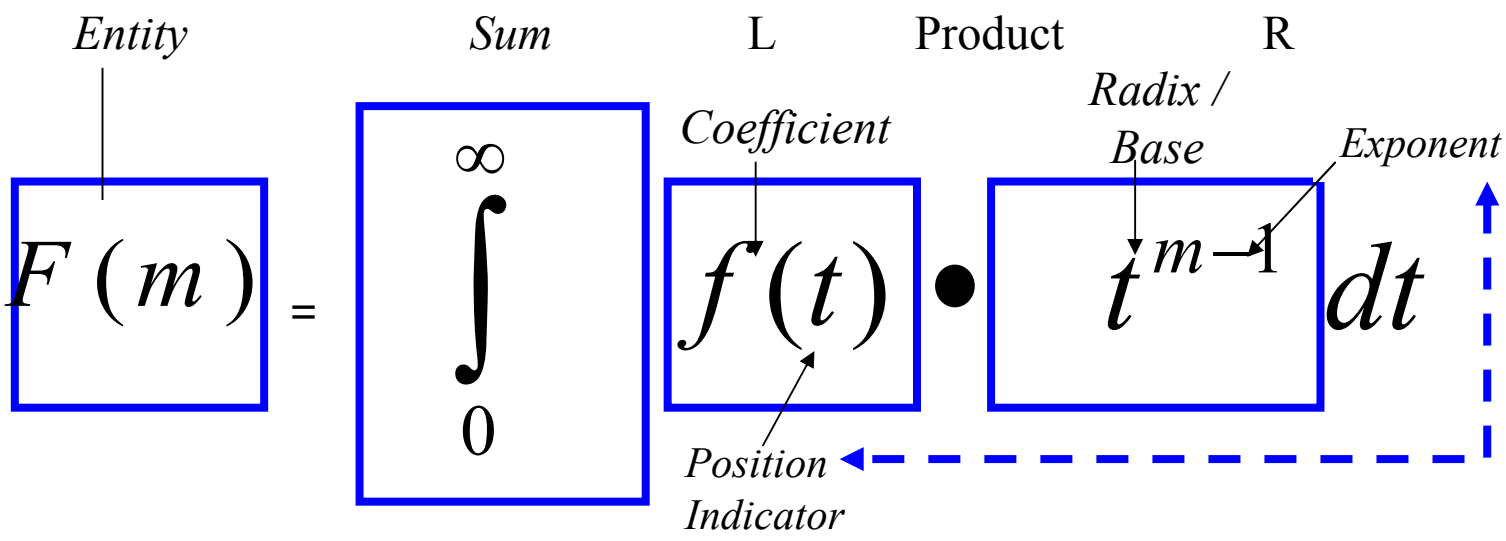
Coefficient : Real, f_k

Position index: k: Positive integer

Position value: $(z^{-1})^k$

Remarks: Positioning natural

Mellin Transform



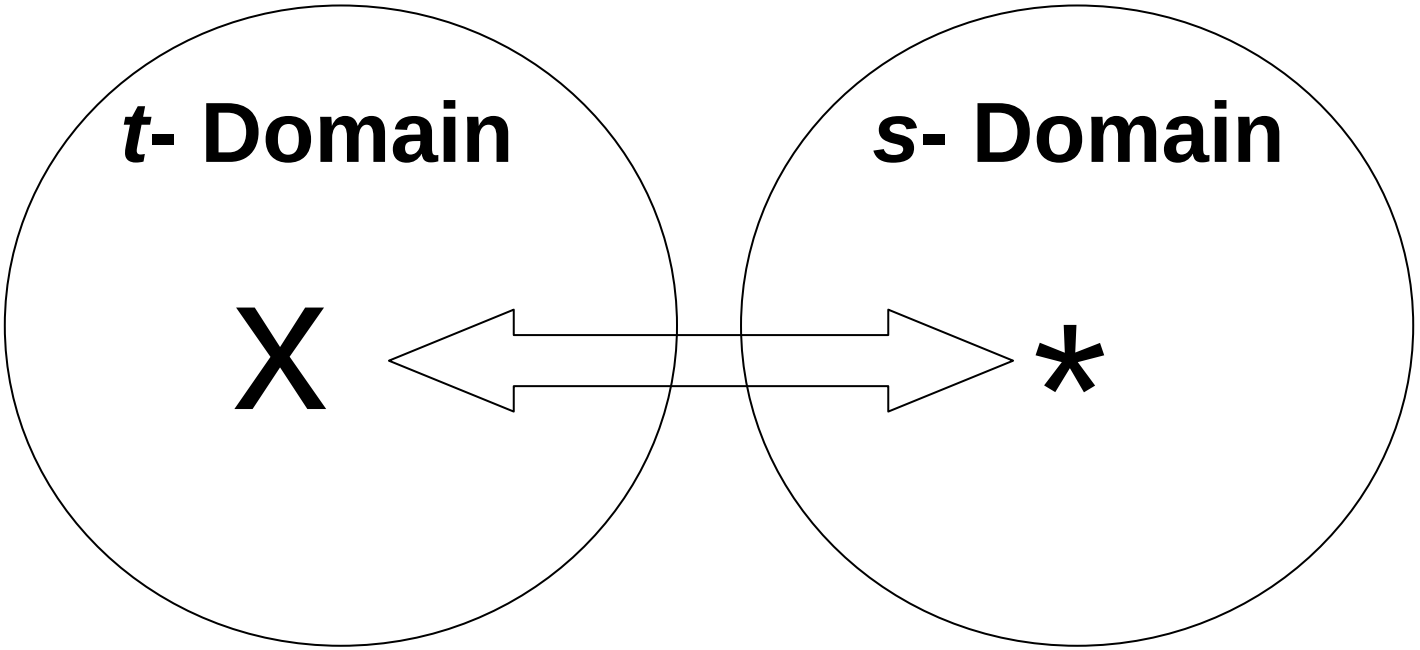
$$f(t) = \frac{1}{2\pi} \oint F(m) t^m dm$$

Radix :	Real, t
Coefficient :	Real $f(t)$
Position index:	t
Position value:	$t^{m\text{-}1}$
Remarks:	Power law

Evolution of various SOP forms of mathematical expression from the Hindu system of number representation

Expression → Features ↓	Number system	Function as power series	Discrete Fourier series of a periodic function	Generalized function	Laplace transform	Fourier transform	z-transform	Mellin transform
Radix (Base)	*Positive integer* $r \geq 2$	*Real*, t	$exp(j\Omega t)$	$\delta(t)$	$exp(-s)$	$exp(-j\omega)$	z^{-1}	*Real*, t
Coefficient	$0 \leq d_k \leq r-1$	*Real*,, f_k	f_k	*Generalized function*	*Real,* $f(t)$	*Real*, $f(t)$	*Real,* f_k	*Real*, $f(t)$
Poisition index (Exponent)	*Integer* k	*Integer,* k	*Integer,* k	*Real,* τ	*Real* $t \in [0, \infty]$ *continuous*	*Real* $t \in [0, \infty]$ *continuous*	*Positive integer,k*	t
Position value	r^k	t^k	$exp(j\Omega t)^k$	$\delta(t-\tau)$	$[exp(-s)]^t$	$[exp(-j\omega)]^t$	$(z^{-1})^k$	t^{m-1}
Remarks	*Word length: Number of digits in the number expression*		*Discrete spectrum: The set of coefficients*	*Natural positioning along* t	*In general* α^{-s} *is also possible.* $\alpha = e$ *normalizes*	*Continuous spectrum*	*Positioning natural*	

Product-Convolution Duality



Product of two numbers

$$M = m_2 r^2 + m_1 r + m_0$$

$$N = n_2 r^2 + n_1 r + n_0$$

$$M.N = (m_2 n_2) r^4 + (m_1 n_2 + m_2 n_1) r^3$$

$$+ (m_0 n_2 + m_1 n_1 m_2 n_0) r^2 + (m_0 n_1 + m_1 n_0) r + m_0 n_0$$

$$= \sum_{j=-(k-1)}^{k-1} \sum_{i=0}^{k-1} m_i r^i n_{i-j} r^{i-j} \quad , k = 3$$

Multiplication by convolution

		m_2	m_1	m_0			
n_2	n_1	n_0					
		$\boldsymbol{m_2\, n_0\, r^2}$					j=-2
		m_2	m_1	m_0			
	n_2	n_1	n_0				
		$\boldsymbol{m_2\, n_1\, r^3}$	$\boldsymbol{m_1\, n_0\, r}$				j=-1
		m_2	m_1	m_0			
		n_2	n_1	n_0			
		$\boldsymbol{m_2\, n_2 r^4}$	$\boldsymbol{m_1\, n_1\, r^2}$	$\boldsymbol{m_0\, n_0}$			j=0
		m_2	m_1	m_0			
			n_2	n_1	n_0		
			$\boldsymbol{m_1\, n_2\, r^3}$	$\boldsymbol{m_0\, n_1\, r}$			j=1
		m_2	m_1	m_0			
				n_2	n_1	n_0	
				$\boldsymbol{m_0\, n_2\, r^2}$			j=2
$\boldsymbol{m_2\, n_2 r^4+(\, m_1\, n_2+\, m_2\, n_1)\, r^3+(\, m_0\, n_2+\, m_1\, n_1+\, m_2\, n_0)\, r^2++(\, m_0\, n_1+\, m_1\, n_0)\, r+\, m_0\, n_0}$							

Integral Transforms: An interpretation

$$F(s) = \int f(t)K(s,t)dt$$

$$f(t) = \int F(s)K^{-1}(s,t)ds$$

Literally

$K(s,t)$: "At t"

$K^{-1}(s,t)$: "At s"

Broader Meaning of Certain Terms

BASIS

SPECTRUM

BANDWIDTH

TUNING

BASIS

A fundamental set of entities chosen to express any other arbitrary entity

Fourier series: **Sinusoidal functions**

Money: **All denominations of coins and notes**

Binary number system: **{0,1}**

Decimal number system: **{0,1,2,3,4,5,6,7,8,9}**

Power series: $\{t^k \ , \ k = 0,1,2,3,.. \quad .\}$

etc…

SPECTRUM

Commonly it is the pattern of sinusoidal components in the information content of a signal

In general it is a pattern that shows how the basis is weighted in a representation.

In our general framework: A sequence of ‘coefficients’.

In the general sense, the following are also ‘spectra’:

A number in the binary system: 110011

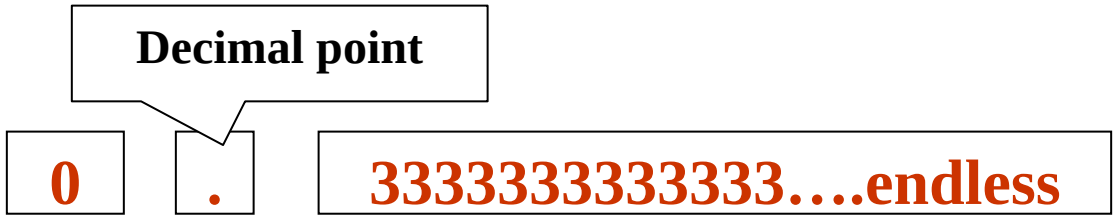
A number in the decimal system: 3456

BANDWIDTH

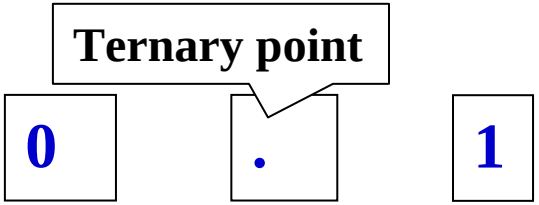
The limits of a sequence of significant coefficients

In number representation, the term ‘word length’ is in the same sense

The number ‘one third’ in the decimal system shows infinite ‘bandwidth’:



In the ternary system the ‘Spectrum’ becomes ‘Band limited’



TUNING

Selecting particular components in a ‘spectrum’

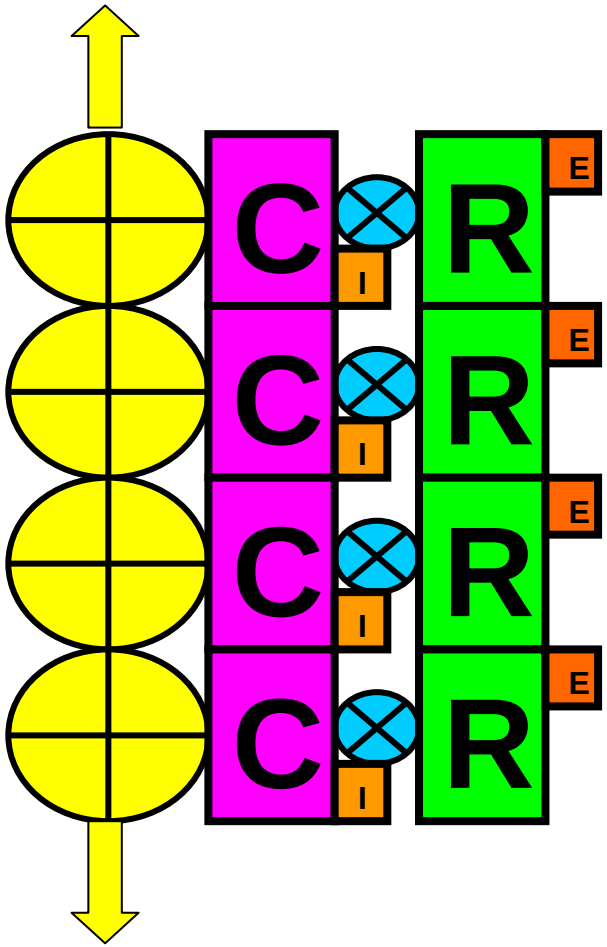
Unusual examples

Finding the digit in the ‘hundreds place’ in the decimal representation of a number

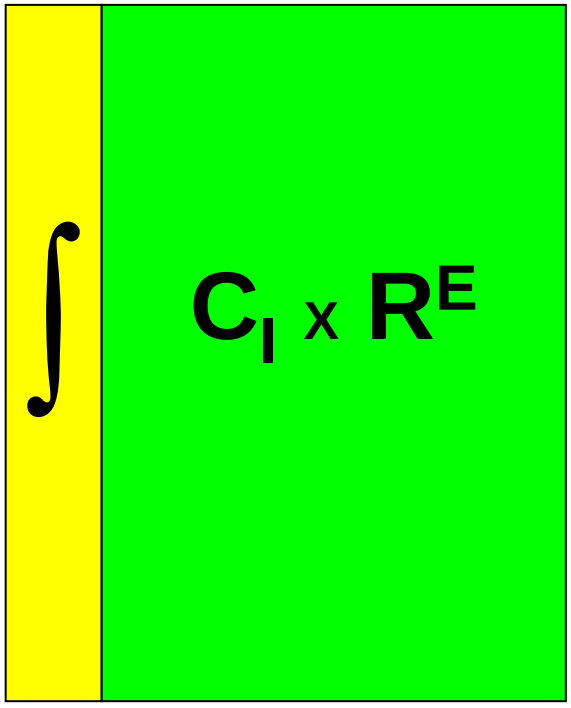
Finding the value of a function $f(t)$ at $t_1>0$

The discrete and continuous DNA-like ribbon models

The discrete ribbon



The continuous ribbon



Some interesting coincidences with 4 of the DNA

- **The number of sub units in the ribbon models is 4**
- **The creator '*Brahma*' is regarded as 4-headed**
- **The perfect '*Dharma*' moves on four '*Paadas*'**
- **The land vertebrate creatures (including humans and other erect walking creatures) predominantly four legged (four limbed). The birds have 2 legs+2wings=4limbs**

Concluding remarks

- The mathematical concepts are not living things to be associated with genetic models. But they are created humans and perhaps, unknowingly, the evolution of concepts follows a similar pattern.
- Let us not look at all these with the usual rigor; in transdiciplinarity, you need to sacrifice some rigor
- Let us not also assess our attempt in terms of direct gains to any of the individual disciplines considered; although in our case study we have gained an interesting insight into a class of mathematical concepts and genetics and philosophy gained nothing
- This is another pursuit of knowledge- the unifying aspect between diverse disciplines

Acknowledgements

I am indebted to

- **my teachers who taught me to how to think,**
- **my students who asked thought provoking questions, and**
- **my friends and colleagues who encouraged my thinking.**

Dedication

- **There was a primary school teacher, who worked in remote and hard-to-access villages, who was also a Vedic and Astro scholar.**
- **I did not go to his school but he was the first to teach me the three R's.**

He inspired this work, provided valuable discussions, and supplied some rare references from ancient Hindu literature.

Born in 1914, he came from a village of scholars like Kavyakantha Ganapati Muni, a long way to Kolkata on 20-12-1998, to rest for ever.

He was my father

Sri Ganti Venkatappadu (1914-1998)

This work is dedicated to his loving memory.

THANK YOU

MAY GOD BLESS YOU ALL