Workshop on

Spins, Games & Networks

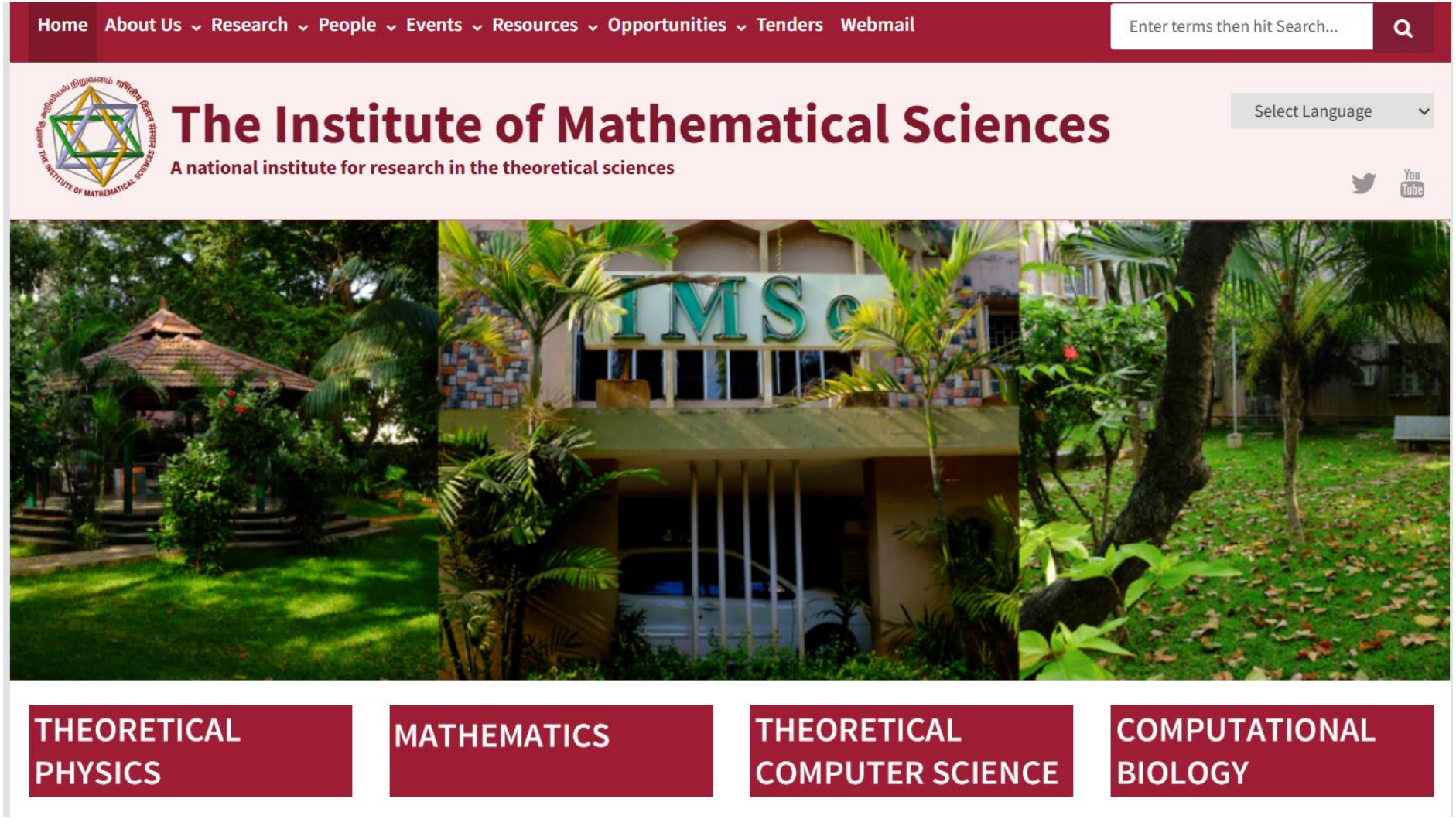
Understanding Collective Coordination in Complex Systems

Noh masks images: Kitazawa Sohta | Prestel 2024

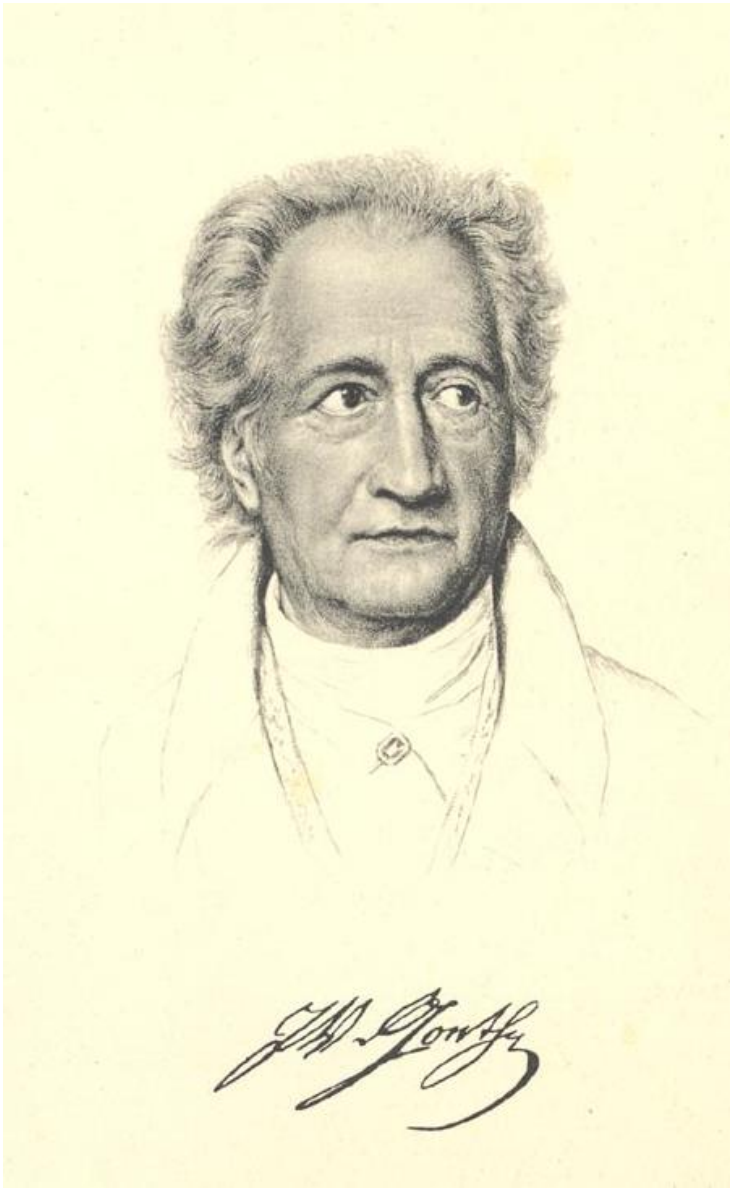
December 11 - 24, 2024

The Institute of Mathematical Sciences
Chennai, India

Welcome to IMSc



What is this workshop about ? The problem



Johann Wolfgang von Goethe

"Who traces life and seeks to give
Descriptions of the things that live
Begins with 'Killing to Dissect'
He gets the pieces to inspect
The lifeless limbs beneath his knife
All parts - but link which gave them life."

- Faust (Part I)

Emergence: More is Different

Why Biology isn't just Physics!

The elementary entities of science X obey the laws of science Y.

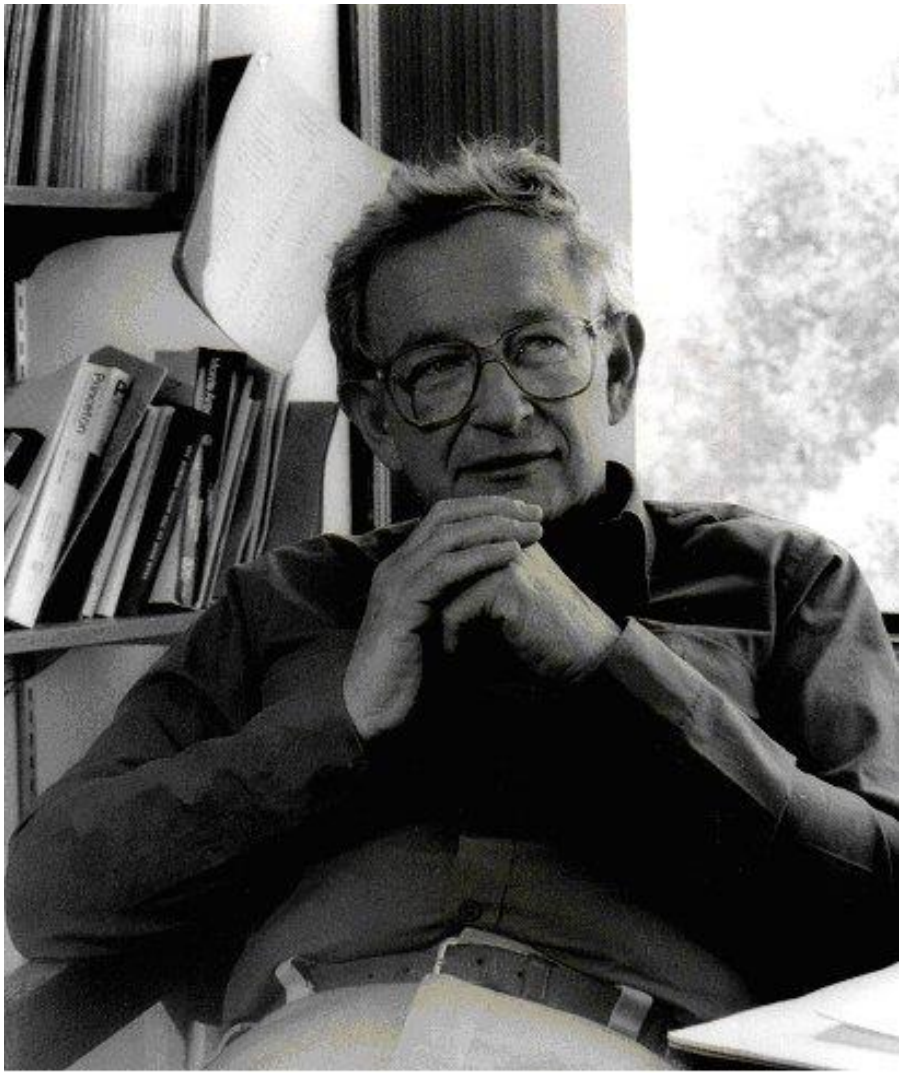
X	Y
solid state or many-body physics	elementary particle physics
chemistry	many-body physics
molecular biology	chemistry
cell biology	molecular biology
•	•
•	•
•	•
psychology	physiology
social sciences	psychology

But this hierarchy does not imply that science X is "just applied Y."

Psychology is not applied biology, nor is biology applied chemistry.

At each stage entirely new laws, concepts, and generalizations are necessary…

P W Anderson, *Science* 1972



Philip W Anderson

Image: wikipedia

Problem: How interactions lead to emergence

The components of complex biological systems are much more complicated than the simple particles of conventional statistical mechanics

Also, in general we are dealing with systems far from equilibrium

The key question

how interactions → novel system-level behavior

E.g., component = individuals,
system = crowd,
emergent behavior = riot

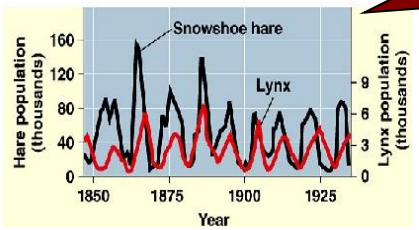
Are there universal organizing principles for biological phenomena & systems in different domains and scales ?

Game-theory strategies

Emergence of Cooperation

Nodal dynamics

Dynamics on Complex Networks

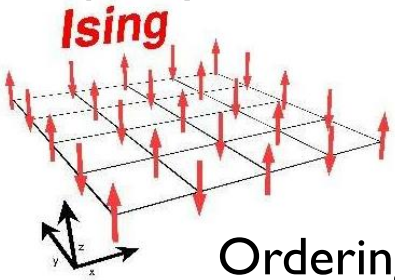


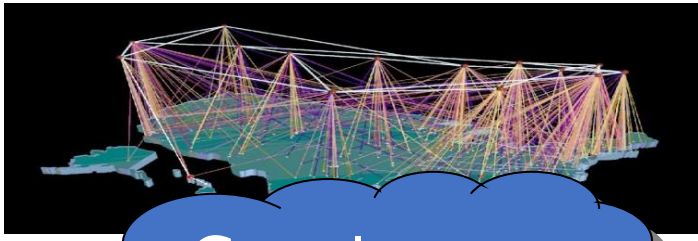
Consensus

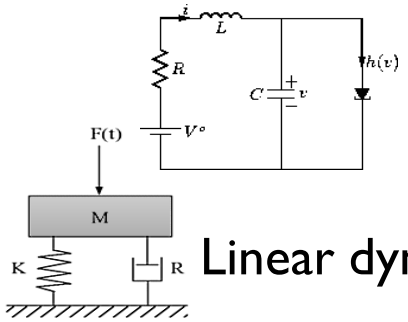
Synchronization

Nonlinear dynamics

Spin systems







Linear dynamics

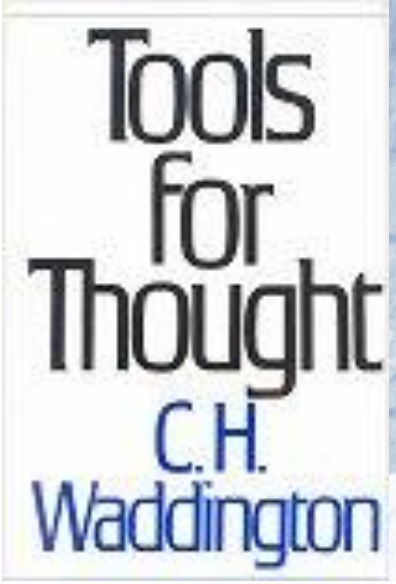
Ordering,
Diffusion,
Contagion Spreading

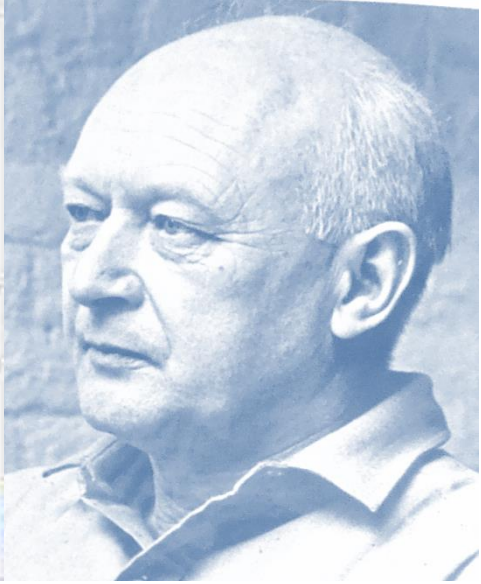
Complex Networks

Complexity of dynamics

Complexity of interconnection

Tools for Thought





Conrad Hal Waddington
(1905-1975)

The developmental biologist Waddington's book *Tools for Thought* (1976) surveys theories and methods for dealing with complex systems, including human beings & societies:

"Considerations of complex shapes, of interactions, of processes, of stabilities, traffic of information and instructions, games theories, forecasting, statistics and more classical scientific analyses…"

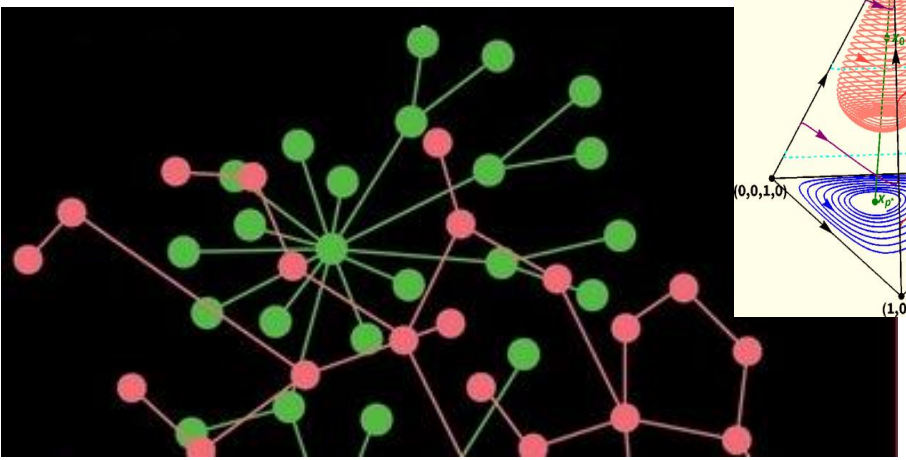
Waddington urged a reassessment of how we think in order to move beyond **COWDUNG** i.e., "Conventional Wisdom of the Dominant Group"

In a very similar spirit

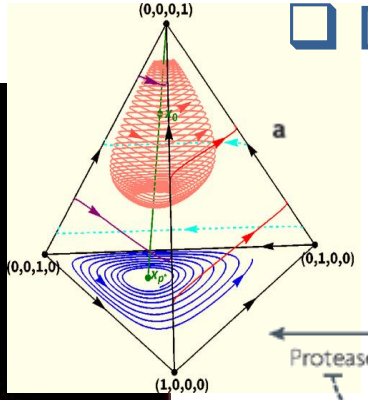
This workshop will attempt to teach you that by applying a set of theoretical abstractions ("mental tools") one can understand analogous phenomena across systems and across scales

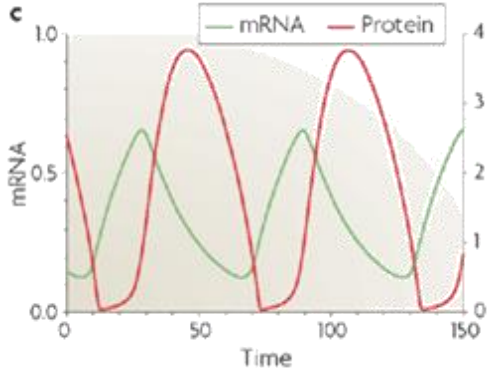
The workshop is organized around several "tools for thinking" about complex systems across various domains

❑ Networks



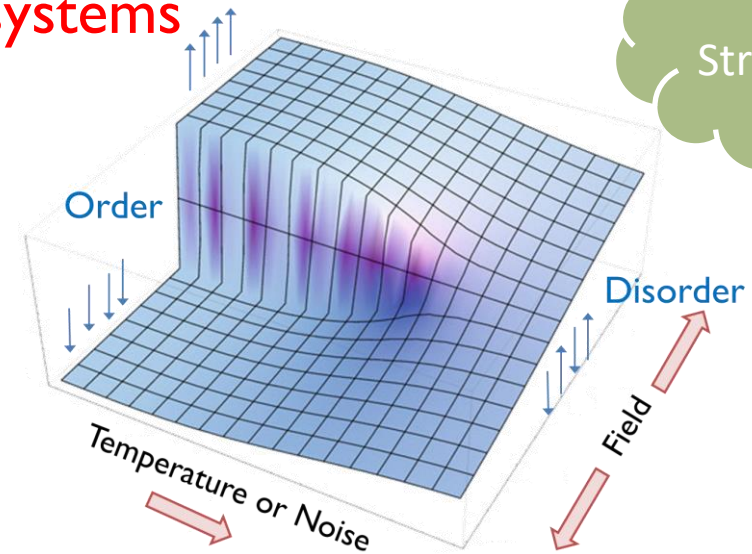
❑ Dynamical Systems



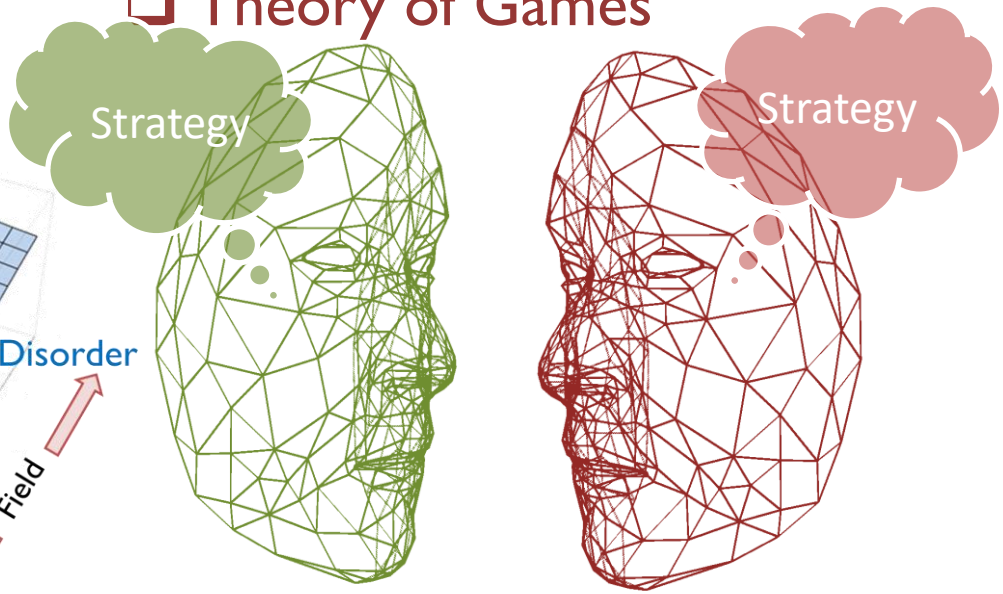


❑ Time-series analysis

❑ Statistical physics of spin systems



❑ Theory of Games



Apart from lectures, also

Group Projects

The groups are expected to be self-organized

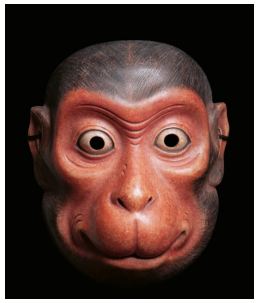
each group ideally comprising 3 participants, each from a different institution

Each group is expected to come up with one or more interesting questions about complex systems (the weirder the better!)

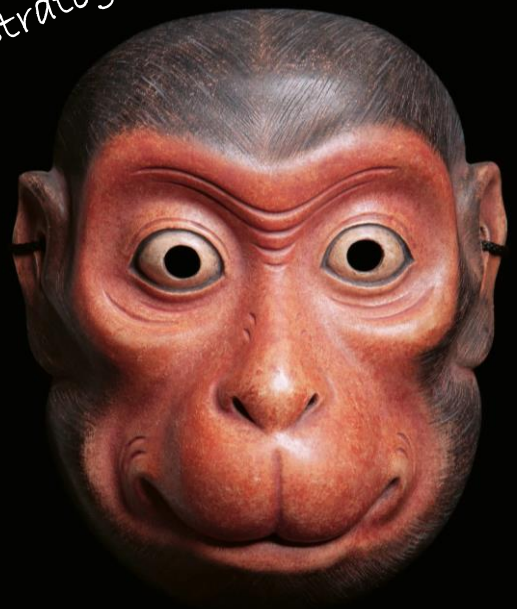
They will work with mentors to mould the question so that it can be addressed using one or more tools taught in the workshop

Any participant is free to talk to any mentor, but for formal mentoring sessions each group will be assigned to any one of four mentor sets by drawing of lots

Mentor Set I	Mentor Set II	Mentor Set III	Mentor Set IV
Anindya & Hareesh	Shakti & Anuran	Sasidevan & Soumyadip	Sitabhra & Saptarshi

Noh characters as Strategies



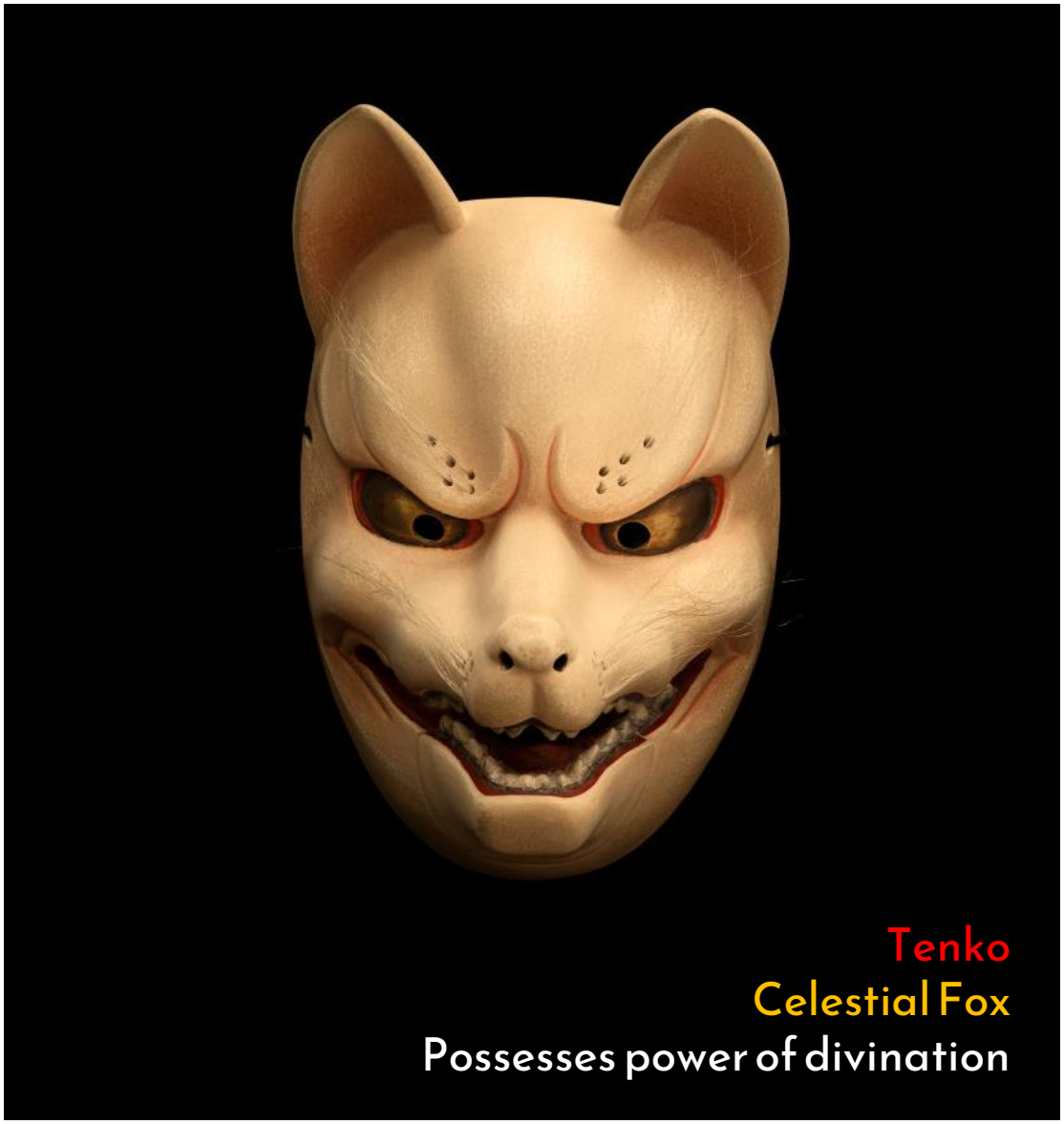
Saru Moku
Monkey
Mischief/
Playfulness

Zo onna
Mother spirit
Wisdom
through Grief

Hannya Bo
Female demon
Jealousy/
Striving for more

Fudo Myoo
Immovable Lord
Destroyer of
evil/Protective

And not to forget the volunteers…



Schedule for

Workshop on *Spins, Games & Networks: Understanding Collective Coordination in Complex Systems*

December 11-24, 2024

Venue: ECG Sudarshan Hall, IMSc

	Wednesday	Thursday	Friday	Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Monday	Tuesday
Time \ Date	Dec-11	Dec-12	Dec-13	Dec-14	Dec-15	Dec-16	Dec-17	Dec-18	Dec-19	Dec-20	Dec-21	Dec-22	Dec-23	Dec-24
10:00-11:00	Sasidevan	Sasidevan	Sasidevan	Shakti		Santhanam	Santhanam	Sagar	Sagar	Sagar			Sushmita	Student Talks
11:00-11:30	TEA/COFFEE					TEA/COFFEE							TEA/COFFEE	
11:30-12:30	Rajesh	Rajesh	Rajesh	Sitabhra		Diptiman	Anuran	Sagar	Sagar	Supratim			Sushmita	Student Talks
12:30-1:30	Shakti	Shakti	Shakti	Anuran		Santhanam	Sagar	Sagar	Supratim	Supratim			Abhijit	Student Talks
1:30-2:30	LUNCH					LUNCH							LUNCH	
2:30-3:30	Sitabhra	Sitabhra	Sitabhra	Anindya		Wolfram	Paolo	Stefan	Anupama	Sandeep			Satyam	Student Talks
3:30-4:00	TEA/COFFEE					TEA/COFFEE							TEA/COFFEE	
4:00-5:00	Anindya	Anindya	Anindya	Group Project Meeting with mentors		Diptiman	Thomas	Supratim	Anupama	Aradhana			Deepak	Valedictory session
5:00-6:00	Mixer Session	Group Project Discussion	Group Project Discussion			Group Projects Mentoring		Group Projects Mentoring		Group Projects Mentoring				

Thanks to

Department of Atomic Energy,
Government of India

IMSc Center of Excellence in
Complex Systems & Data Science