# STRING THEORY AND QUANTUM GRAVITY

**H**ow do we understand the origin of the universe - the big bang?

**W**hat are the fundamental interactions in nature?

**W**hat happens inside a black hole?

**C**an we understand the behaviour of states of matter in extreme conditions?

**H**ow do we describe the transitions between various states of matter?

**W**hy are strings fundamental objects of physics?
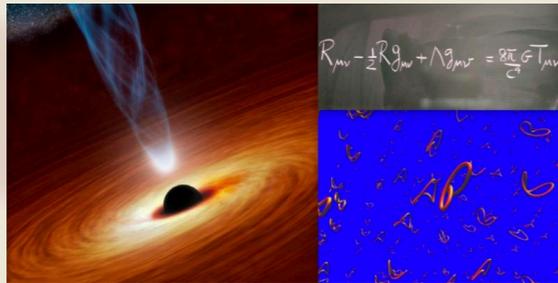
Rajesh Gopakumar · Raghu Mahajan · Loganayagam R. · Suvrat Raju · Ashoke Sen · Spenta R. Wadia

# COMPUTER SCIENCE

**W**hat makes some problems hard for computers to solve?

**H**ow do classical and quantum randomness help efficient computation?
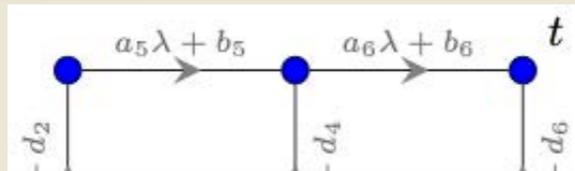
Jaikumar Radhakrishnan

# ASTROPHYSICS & RELATIVITY
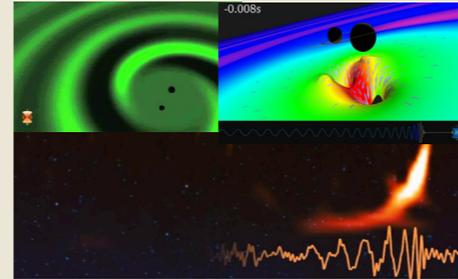
**I**s Einstein's General Theory of Relativity the correct (classical) description of gravity?

**W**hat is the nature of gravity in highly dynamical astrophysical situations?

**A**re nature's black holes the same as the black holes of General Relativity?

**H**ow does the Universe form merging binary systems of black holes?

**D**o primordial black holes exist?

**I**s (at least a part of) the elusive "dark matter" constituted by compact objects such as black holes?

**W**hat is the origin of big beautiful magnetic fields in stars, galaxies, accretion disks?

**H**ow can we understand typical energetic events occurring in astrophysical plasmas?

P. Ajith · Pallavi Bhat · Bala Iyer · Prayush Kumar · Rajaram Nityananda · Joseph Samuel

# APPLIED & COMPUTATIONAL MATHEMATICS

Amit Apte · Mythily Ramaswamy · Jim Thomas · Vishal Vasan
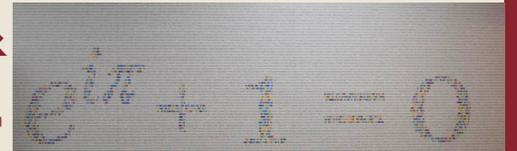
**W**ill a marriage of (too noisy) data with (too chaotic) dynamics predict the future accurately?

**I**f it rains here, where else will it rain? Should we even try to predict rain with certainty?

**W**hy are patterns formed and why do they persist? Can we engineer specific patterns or use them to infer system details?

**H**ow can we use mathematics to model the randomness and understand large scale systems?

# GEOMETRY & PHYSICAL MATHEMATICS

Anatoly Fomenko

**W**hat is the beautiful math behind soap films and bubbles?

**W**hat mathematical structures are needed to describe Nature at the smallest scales?

**H**ow can heuristics from theoretical physics be leveraged to uncover mathematical truths?
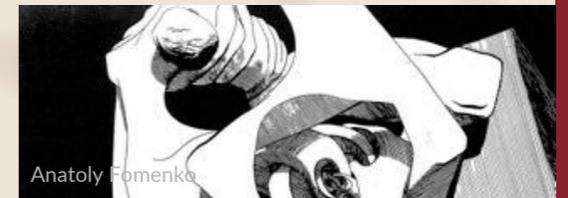
Rukmini Dey · Pranav Pandit · T.N. Venkataramana

**ICTS**

# CONDENSED MATTER & STATISTICAL PHYSICS

Subhro Bhattacharjee  
Chandan Dasgupta  
Abhishek Dhar  
Deepak Dhar  
H.R Krishnamurthy  
Manas Kulkarni  
Anupam Kundu  
Sumathi Rao  
Sthitadhi Roy  
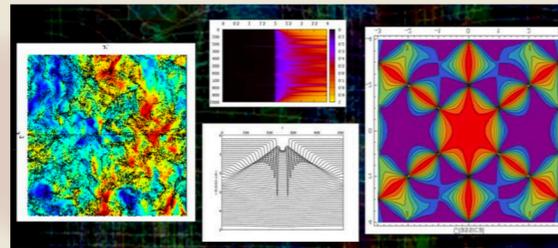
**W**hat is the probability of rare and extreme events and large deviations in physical systems like current fluctuations in nanoscale systems ?

**W**hat is the fundamental physics in the design of novel quantum devices like diodes, transistors, lasers etc?

**H**ow does the physics of glass-like and liquid-like behaviour of cells apply to biological systems (wound healing, spreading of cancer etc) or dense systems (self-propelled objects such as bacteria, birds and fish etc)?

**H**ow do quantum effects manifest in many-particle systems around us?

**W**hat is the origin of the arrow of time and how does irreversibility arise from reversible microscopic laws?

# BIOLOGICAL PHYSICS

Brato Chakrabarti  
Akshit Goyal  
Vijaykumar Krishnamurthy  
Sriram Ramaswamy  
Shashi Thutupalli  
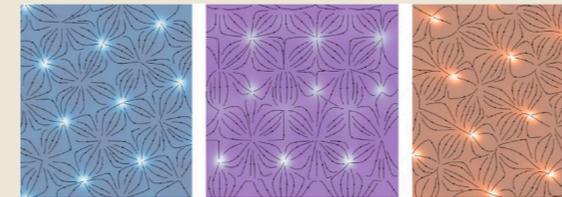
**H**ow do living organisms generate the shapes of their various body parts? What is the physics behind the emergence of these geometrical shapes?

**H**ow does a cell arise in the first place? What is the minimal configuration for a cell?

# PROBABILITY THEORY

Siva Athreya  
Anirban Basak  
Riddhipratim Basu  

**H**ow can we use mathematics to model the randomness and understand large scale systems?

**W**hat are good stochastic algorithms to solve optimisation problems on large real world networks?

**H**ow to develop vaccination strategy that ensures vaccine-preventable diseases are eliminated?

# FLUID DYNAMICS & TURBULENCE

Amit Apte  
Pallavi Bhat  
Brato Chakrabarti  
Rama Govindarajan  
Debasis Sengupta  
Samriddhi Sankar Ray  
Jim Thomas  
Vishal Vasan  
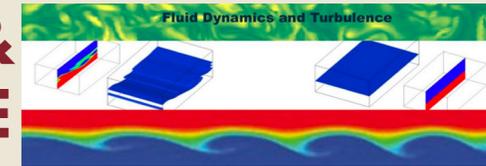
**W**hy do knotted vortices tend to unknot? How does this affect turbulence?

**H**ow does the addition of dust affect the laminar-turbulent transition?

**W**hich clouds will rain?

**H**ow can we compute the dynamics of small particles in fluid at low computational cost?

**H**ow do interacting particles behave in flow?