ITU International Science and Engineering Summit (SES) 2026

Report of Contributions

Contribution ID: **2** Type: **not specified**

Modern Cosmology: Foundations, Challenges, and the Search for Solutions

Wednesday 6 May 2026 15:50 (1 hour)

Modern cosmology provides a powerful framework for describing the Universe, from the Copernican principle to Einstein's general relativity and the standard cosmological model, ΛCDM. Despite its remarkable success, however, this model now faces serious challenges, most notably the Hubble tension: a persistent mismatch between early-Universe predictions and late-Universe observations. In this talk, we will introduce the foundations of modern cosmology, discuss why current cosmological tensions may point to missing physics, and outline some of the ideas being explored in the search for possible solutions. Particular emphasis will be placed on the possibility that the dark sector may be richer than assumed in ΛCDM, motivating a rethinking of the cosmological constant and the search for a new concordance model.

Presenter: Prof. AKARSU, Özgür (Istanbul Technical University)

Session Classification: Cosmology Session

Contribution ID: **3** Type: **not specified**

Quantum-Squeezed Light –Routine Improvement of Gravitational Wave Observations

Tuesday 5 May 2026 10:30 (1 hour)

Light with squeezed quantum uncertainty allows for the sensitivity improvement of laser interferometers. In 2011, the GEO600 gravitational wave detector used squeezed light in its joint search for gravitational waves with Virgo [1,2]. The successful sensitivity improvement triggered the implementation of squeezed light sources also in Advanced LIGO and Advanced Virgo. On April 1st, 2019 these observatories started their third observational run. Since then, they have been detecting more than one GW event per week. An increased event rate of up to 50% is due to the exploitation of squeezed states of light [3–5]. Squeezed light is fully described by quantum theory, however, observations on squeezed light represent physics that is not self-evident. I present a description of why a squeezed photon counting statistic is rather remarkable.

[1] LIGO Scientific Collaboration, Nature Physics 7, 962 (2011);

[2] H. Grote et al., Phys. Rev. Lett. 110, 181101 (2013);

[3] M. Tse et al., Phys. Rev. Lett. 123, 231107 (2019);

[4] F. Acernese et al., Phys. Rev. Lett. 123, 231108 (2019);

[5] R. Abbott et al., Phys. Rev. X 11, 021053 (2021).

Presenter: SCHNABEL, Prof. Dr. Roman

Session Classification: Quantum Optics Session

Contribution ID: **4** Type: **not specified**

Scanning Probe Microscopy in Nanoscience: From Classical to Quantum Concepts

Tuesday 5 May 2026 11:45 (1 hour)

This talk presents an overview of the applications of Scanning Probe Microscopy (SPM), with particular emphasis on the Scanning Tunneling Microscope (STM) and Atomic Force Microscope (AFM). The role of SPM in surface science through atomic-scale imaging will be highlighted. In addition, precision nanometer-scale machining using AFM will be discussed, with examples from our works, including the manipulation and characterization of graphene. Finally, the integration of AFM techniques into emerging quantum technologies will be addressed, focusing on its application in quantum magnetometry based on solid-state spin systems.

Presenter: ÖZER, Prof. Dr. Hakan Özgür

Session Classification: Nanotechnology Session

Contribution ID: **5** Type: **not specified**

Quantum Computing: From Theory to Engineering Practice

Tuesday 5 May 2026 13:45 (1 hour)

Quantum computing is often introduced as a fundamentally new computational paradigm. However, beyond its theoretical foundations, it is increasingly becoming an engineering discipline that spans multiple layers, from abstract algorithms to physical implementations. In this talk, we present a structured overview of quantum technologies through an "engineering stack"perspective. Starting from the motivation behind quantum computation, we discuss how quantum algorithms, noise-aware modeling, control techniques, and quantum optical implementations are interconnected in practice. We further highlight the emerging need for engineers who can operate across these layers, especially in the context of near-term quantum devices. Selected examples from ongoing research, including device-level simulations and quantum optimization studies, will be presented to illustrate these concepts. Finally, we briefly discuss recent initiatives at Istanbul Technical University, including efforts toward establishing a graduate program in Quantum Computing and Technologies, as well as industry-oriented activities through the Qready initiative.

Presenter: TÜRKPENÇE, Assoc. Prof. Deniz

Session Classification: Quantum Computing Session

Contribution ID: **6** Type: **not specified**

Entropic Forces

Wednesday 6 May 2026 10:30 (1 hour)

According to the second law of thermodynamics, systems always evolve toward states with higher entropy that means higher number of possible configurations. When a system is constrained, it resists these constraints to regain its freedom, thereby generating a measurable macroscopic force, called “entropic force”.
Essentially, entropic force is a physical observable force, in which a system moves not because of underlying fundamental forces such as electromagnetism or gravity, but because this movement increases the overall disorder of the system.

Presenter: REZA EJTEHADI, Prof. Dr. Mohammad

Session Classification: Thermodynamics Session

Contribution ID: **7** Type: **not specified**

What Einstein did not Know: Anomalous Diffusion, from Pilot Balloons to Hydrology

Wednesday 6 May 2026 11:40 (1 hour)

Robert Brown reported the jiggling motion of micron-sized pollen granules observed in his microscope in 1828. Since this first observation of diffusion, experimental techniques have been advanced massively. Today, for instance, individual molecules diffusing in living biological cells can be followed at the resolution of few nanometres at millisecond intervals. Such measured trajectories reveal a lot about the physical properties of their environment.

To extract this information, dedicated models need to be established and analysed. This is at the core of modern non-equilibrium statistical physics. In my talk I am going to address several aspects of what we call anomalous diffusion, when the measured dynamics deviates from that of normal Brownian motion. The earliest example is so-called Richardson diffusion in turbulent media, as measured by pilot balloos experiments in 1926. Other examples include motion characterised by energetic trapping and processes with long-range correlations.

The physical phenomena addressed in the talk include (weak) non-ergodicity, non-exponential relaxation, long-time retention effects in hydrology, non-Gaussian behaviour, and boundary effects.

Presenter: METZLER, Prof. Dr. Ralf

Session Classification: Biophysics Session

Contribution ID: **8** Type: **not specified**

Information Field Theory: Concepts & Astrophysical Applications

Wednesday 6 May 2026 14:40 (1 hour)

Fields play a central role in all areas of astrophysics, like the density, velocity, magnetic, or gravitational field. Inferring an astrophysical field from data is an ill posed problem, as the finite, noisy, and incomplete data can not alone constrain the infinite number of degrees of freedom of a function over continuous space. Domain knowledge has to regularize the set of possible solutions, however, usually significant uncertainties remain and need to be quantified. This can be done via information field theory (IFT), which is a mathematical formulation of probabilistic field inference. Here, the basic concepts of IFT and its numerical implementation are introduced. Its application to astrophysical datasets is shown for the ongoing project to build an atlas of the Milky Way.

Presenter: ENSSLIN, PD Dr. Torsten

Session Classification: Astrophyiscs Session

Contribution ID: **10** Type: **not specified**

Analyzing complex networks of social systems: from scientists to social media bots

Tuesday 5 May 2026 15:00 (1 hour)

Social systems exhibit complex behavior, and more recently these systems have been studied using tools of network science and machine learning. In this talk, I will present various complex systems like scientists referring to literature either by citing them or simply referring to them as text or social media accounts coordinating towards spreading misinformation online. Diffusion of scientific knowledge led us to discover "hidden citations"that emerge when a scientific concept is discussed more frequently, it suffers significant credit loss measured by traditional citation metrics regardless of publishing venue and discipline. Similarly, popularity of social media influencers follows quantized patterns between popularity and influence. We also discuss when such systems disturbed by automated accounts and risks involved in manipulating public discourse. I hope to convince you that both these systems share unique characteristics that are of interest to Physicists and Computer Scientists.

Presenter: VAROL, Asst. Prof. Onur

Session Classification: Machine Learning and Data Analysis Session

Contribution ID: **11** Type: **not specified**

Journey to the Smallest: CERN and the Higgs Boson

Wednesday 6 May 2026 13:30 (1 hour)

This talk will take us on a journey, from an experimental and theoretical perspective, towards the smallest building blocks of matter, discussing the Large Hadron Collider at CERN and the discovery of the Higgs boson.

Presenter: ÖZTÜRK, Prof. Dr. Sertaç

Session Classification: High Energy and Particle Physics