Universität Hamburg
DER FORSCHUNG | DER LEHRE | DER BILDUNG

SUMMER SCHOOL *PARTICLES, STRINGS & COSMOLOGY 2021*

Universität Hamburg hereby confirms, that Mr Devansh Shukla successfully participated in the virtual Summer School course for **Particles, Strings & Cosmology** held virtually from 05 July 2021 to 30 July 2021 at Universität Hamburg, Germany.

Universität Hamburg is the largest university in Northern Germany. Hamburg provides a unique research environment for interdisciplinary research at the interfaces of particle physics, astrophysics and cosmology. Researchers from Universität Hamburg's physics department and the German Electron Synchrotron (DESY) taught online courses on theoretical concepts that deepened the students' knowledge in the fields of particles, strings and cosmology

During the four-week virtual summer program at Universität Hamburg, Mr Devansh Shukla learned from leading scientists. He examined theoretical concepts to deepen his knowledge in the above named fields and discussed advanced research questions with different peer groups. The physics program was complemented by online sessions on German cultural and regional studies. In addition, Mr Devansh Shukla completed a mandatory language course in basic German.

The program comprised the courses listed on the next pages.

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In cooperation with

DESY

Universität Hamburg
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SUMMER SCHOOL *PARTICLES, STRINGS & COSMOLOGY 2021*

CONFIRMATION OF PARTICIPATION

Mr Devansh Shukla

successfully participated in the Summer School course for **Particles, Strings & Cosmology** held virtually from 05 July 2021 to 30 July 2021 at Universität Hamburg, Germany.

Content:

Physics Program

- Module 1: General Relativity — Grade: *1.7*, — Credits: *1.0 (ECTS)*
- Module 1: Quantum Field Theory — Grade: *not graded*, — Credits: *1.5 (ECTS)*
- Module 2: Modern Topics in Cosmology — Grade: *not graded*, — Credits: *1.5 (ECTS)*
- Module 2: Particles — Grade: *1.3*, — Credits: *1.5 (ECTS)*
- Module 2: String Theory — Grade: *1.7*, — Credits: *1.0 (ECTS)*

Complementary Program

- Hamburg – a musical History, Signs in the City: Hamburg's linguistic Landscape, Good scientific Practice

Grade: *not graded*, Credits: *0.5 (ECTS)*

Language Course

- Language Course in basic German

Grade: *not graded*, Credits: *1.0 (ECTS)*

Hamburg, 30 July 2021

Kristin Günther
Coordination—Hamburg International Summer School

http://www.uni-hamburg.de/summerschools

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PHYSICS PROGRAM

Module 1: General Relativity (10 hours, acad.)

- Einstein's general theory of relativity describes gravity as the consequence of a curvature of space and time sourced by matter. This course gives an elementary introduction to general relativity with a focus on the equivalence principle, basics of differential geometry, the Einstein equation and applications.

Module 1: Quantum Field Theory (20 hours, acad.)

- Quantum field theory combines the principles of special relativity and local field theory with those of quantum mechanics. This course gives a compact introduction to this subject including classical field theory, free quantum fields, interactions, Feynman diagrams and renormalization.

Module 2: Modern Topics in Cosmology (20 hours, acad.)

- This course gives an overview of and introduction to modern and timely topics in cosmology. It focuses on the main theoretical concepts covering cosmic times ranging from the creation of primordial density fluctuations to the onset of structure formation. Observational signatures will be presented qualitatively and further developed in a separate module.

Module 2: Particles (22 hours, acad.)

- The course describes the standard model of particle physics, its experimental tests and its limitations. It covered detectors at modern colliders, tests of Quantum Chromodynamics and electroweak interactions, the discovery of the Higgs boson at the LHC and searches for dark matter and new physics.
- This module consists of the courses Introduction to Particle Physics, Quantum Chromodynamics, Weak Interactions, Higgs, Machine Learning and Beyond the Standard Model

Module 2: String Theory (10 hours, acad.)

- String theory is a promising candidate for a unified theory of all particles and interactions that also encompasses a quantum theory of gravity. This course gives an elementary introduction to string theory with focus on classical and quantized bosonic strings, interactions, D-branes and superstrings.

Grades

ECTS-Grades	A - excellent		B - very good		C - good		D - satisfactory		E - sufficient		F - failed
UHH	1.0	1.3	1.7	2.0	2.3	2.7	3.0	3.3	3.7	4.0	5.0

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COMPLEMENTARY PROGRAM (8 hours, acad.)

Hamburg – A Musical History

- This seminar shows Hamburg's music – from some of the city's earliest musical manuscripts to early performances in the Kiez and investigated some of the city's more notorious musical events.

Signs in the City: Hamburg's linguistic Landscape

- This seminar offers an introduction to Hamburg from the viewpoint of its linguistic landscape, i.e. signs in urban space.

Good Scientific Practice

- This seminar gives an introduction to good scientific work and research methods.

LANGUAGE COURSE (16 hours, acad.)

A one-week language course in basic German to get an understanding of the language and the culture behind it.

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