



हरीश चन्द्र अनुसंधान संस्थान

छतनाग मार्ग, झूँसी, इलाहाबाद - 211 019

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Major achievements for the Month - August 2016

**In
Physics
&
Mathematics**

STRING THEORY

1. Entangled spins and ghost-spins (Dileep P. Jatkar, K. Narayan)

We study patterns of quantum entanglement in systems of spins and ghost-spins regarding them as simple quantum mechanical toy models for theories containing negative norm states. We define a single ghost-spin as in arXiv:1602.06505 [hep-th] as a 2-state spin variable with an indefinite inner product in the state space. We find that whenever the spin sector is disentangled from the ghost-spin sector (both of which could be entangled within themselves), the reduced density matrix obtained by tracing over all the ghost-spins gives rise to positive entanglement entropy for positive norm states, while negative norm states have an entanglement entropy with a negative real part and a constant imaginary part. However when the spins are entangled with the ghost-spins, there are new entanglement patterns in general. For systems where the number of ghost-spins is even, it is possible to find subsectors of the Hilbert space where positive norm states always lead to positive entanglement entropy after tracing over the ghost-spins. With an odd number of ghost-spins however, we find that there always exist positive norm states with negative real part for entanglement entropy after tracing over the ghost-spins.

Cite as: arXiv:1608.08351 [hep-th] (or arXiv:1608.08351v1 [hep-th] for this version)

2. Two talks were presented by Professor Ashoke Sen

- ***Some applications of string field theory: Dealing with infrared issues***, talk given at **Strings 2016 conference in Beijing** from August 1-5, 2016
- ***Applications of superstring field theory***, talk given at **Strings and Fields, 2016** conference in **Kyoto** from August 8-12, 2016.

Achievements in Mathematics

Number Theory

1. A paper D. Surya Ramana jointly authored with J. Cilleruelo and O. Ramare, was accepted for publication in the Proc. Steklov Inst. of Math., where they study the cardinalities of A/A and AA for thin subsets A of the set of the first n positive integers. In particular, they consider the typical size of these quantities for random sets A of zero density and compare them with the sizes of A/A and AA for subsets of the shifted primes and the set of sums of two integral squares.

2. **Azizul Hoque and Kalyan Chakraborty:** Divisibility of class numbers of certain families of quadratic fields.

Brief: We construct some new families of quadratic fields whose class numbers are divisible by 3. The main tools used are a trinomial introduced by Kishi and a parametrization of Kishi and Miyake of a family of quadratic fields whose class numbers are divisible by 3. At the end we compute class number of these fields for some small values and verify our results.

Status: Communicated.

3. A book was published in August 2016

Title: A Quick Introduction to Complex Analysis

Authors: Kalyan Chakraborty, Shigeru Kanemitsu and Takako Kuzumaki

Publisher: World Scientific Publishing Co. Pte. Ltd., Singapore.

Brief: The book is aimed at giving a smooth pathway from Calculus to Complex Analysis by way of plenty of examples and worked out problems. The book helps the reader to acquire fundamental skills of understanding the subject and its applications. It's an undergraduate text and will also be useful for engineering students.