

## Punita Batra

### Research Summary:

In a joint work with Santanu, I have classified integrable representations for extended affine Lie algebras, where the center is acting trivially on the modules. Along with Hiroyuki Yamane, I am trying to give a serre type presentation for higher rank toroidal Lie superalgebras.

### Preprints:

1. Santanu Tantubay, Punita Batra, *Classification of irreducible integrable modules for extended affine Lie algebras with center acting trivially*, arXiv:2105.02000v1 [math.RT].

### Conference/Workshops Attended:

1. *The 35th Annual Conference of the Ramanujan Mathematical Society (online)* at the Central Univ. of Rajasthan, December 27-30, 2020.

### Invited Lectures/Seminars:

1. *Integrable representations of loop-toroidal Lie algebras*, Invited online talk in the Algebra Symposium, The 35th Annual Conference of the Ramanujan Mathematical Society, Central University of Rajasthan, December 27, 2020.

### Other Activities:

1. A member of the DST-FIST subject expert committee- Mathematical Sciences since September 2020.
2. As part of an outreach activity of HRI, I gave an online talk for High school students on March 21, 2021.
3. Taught a Ph. D course Algebra-I to first year students during January-May 2021 at HRI.
4. My Ph.D student Souvik Pal has submitted his Ph.D thesis in June 2021 under my supervision.
5. I am a member of the Outreach Programme at HRI. Also serving as a member in the Sports and Entertainment Committee and the Rajbhasha Committee at HRI.

## AseshKrishna Datta

### Research Summary:

During the academic year 2020-2021, I had to confine my research activities within the broad area of search for Supersymmetry (SUSY) at the Large Hadron Collider (LHC) and its connection to Cosmology, in particular, to dark matter (DM) phenomenology, vacuum stability, electroweak phase transitions (EWPT) in the early Universe and electroweak baryogenesis (EWBG).

In a work that got accepted in *JHEP* earlier this year, I, along with my graduate student and a postdoctoral fellow from our Institute, presented a detailed study on the viability of a relatively light, highly bino-like neutralino dark matter in the  $Z_3$ -symmetric Next-to-Minimal SUSY Standard Model (NMSSM). We demonstrated that, in contrary to the existing notion, such a neutralino can be as light as a few tens of a GeV and can still be consistent with all pertinent constraints.

Viability of such a light electrowino, which is the Lightest SUSY Particle (LSP), paves the way for the possible presence of other such light states which might escape detection at the LHC under diverse circumstances that warrant thorough studies. I, along with the same graduate student and a faculty member from an Indian institute, am finishing a work where we are looking into such a possibility within the NMSSM, in the presence of light singlet-like scalars of the scenario. Such a scenario is rather congenial to a triggering of a first order EWPT in the early Universe leading to EWBG that can explain the observed baryon asymmetry in the Universe. The connection to gravitational waves originating during the process is also in the context.

In two different collaborations, with faculty members from institutes abroad and my other graduate student, I have been studying the novel phenomenology of relatively light electrowinos of the  $B - L$  SUSY Standard Model (BLSSM) that could have evaded the latest LHC searches. Another project that is nearing completion studies the novel LHC phenomenology of a rather fat  $Z'$ -like resonance in the said framework.

In another collaboration, with a faculty members from an Indian institute and two postdoctoral fellows from two different institutes, I have been exploring the interesting dependencies of the bottom and the tau Yukawa couplings on the parameters of a SUSY scenario like the Non-Holomorphic SUSY Standard Model (NHSSM), over and above their well-known dependencies on a parameter like  $\tan \beta$  and their implications for the LHC.

### Publications:

1. AseshKrishna Datta, with Waleed Abdallah and Subhojit Roy, *A relatively light, highly bino-like dark matter in the  $Z_3$ -symmetric NMSSM and recent LHC searches*, arXiv:2012.04026 [hep-ph] (accepted for publication in Journal of High Energy Physics (JHEP)).

### Preprints:

1. AseshKrishna Datta, with Waleed Abdallah and Stefano Moretti, *A fat  $Z'$  in the  $B - L$  supersymmetric Standard Model*, (in preparation).

2. AseshKrishna Datta, with Utpal Chattopadhyay, Samadrita Mukherjee and Abhaya Kumar Swain, *Production of heavier Higgs bosons in association with bottom quark(s) at the LHC as a probe to Nonholomorphic MSSM*, (in preparation).
3. AseshKrishna Datta, with Arindam Chatterjee and Subhojit Roy, *Light scalars and electrowinos of the NMSSM: Implications for Electroweak Baryogenesis and LHC searches*, (in preparation).
4. AseshKrishna Datta, with Waleed Abdallah and Afsar Reja, *Light electrowinos of the  $B - L$  supersymmetric Standard Model at the LHC*, (in preparation).

### Conference/Workshops Attended:

1. *Anomalies 2020*, IIT, Hyderabad, India, September, 2020 (online workshop).
2. *Tools 2020*, IP2I, Lyon, France, November, 2020 (online workshop).
3. *Less Travelled Path of Dark Matter*, ICTS, Bangalore, India, November, 2020 (online workshop).

### Visits to other Institutes:

None; due to the prevailing COVID-19 pandemic.

### Invited Lectures/Seminars:

None. *Had to decline several opportunities as I have been dealing with major harassments (that I am facing at my workplace) at the highest level.*

### Other Activities:

1. Supervising two graduate students towards their Ph.D. theses.
2. Mentored a student in two mandatory projects during his graduate course work.
3. Serving doctoral committees of several graduate students.
4. In the panel of referees of various international journals.
5. Served as a member of the Physics Outreach Programme Committee and the Sports and Entertainment Committees at HRI.

## Ujjwal Sen

### Research Summary:

In the last academic year, I have been working on different aspects of quantum devices, and at the interface of quantum information with other sciences.

In one of these works, I have collaborated with Ahana Ghoshal on heat current and entropy production rate in local non-Markovian quantum dynamics of a global Markovian evolution. We examined the elements of the balance equation of entropy in open quantum evolutions, and their response as we go over from a Markovian to a non-Markovian situation. In particular, we looked at the heat current and entropy production rate in the non-Markovian reduced evolution, and a Markovian limit of the same, experienced by one of two interacting systems immersed in a Markovian bath. The analysis naturally led us to define a heat current deficit and an entropy production rate deficit, being differences between the global and local versions of the corresponding quantities. The investigation brought us, in certain cases, to a complementarity of the time-integrated heat current deficit with the relative entropy of entanglement between the two systems.

In another work, I have collaborated with Kornikar Sen and Chirag Srivastava to provide measurement-device-independent nonlinear entanglement witnesses. Entanglement witnesses are one of the most effective methods to detect entanglement. It is known that nonlinear entanglement witnesses provide better entanglement detection than their linear counterparts, in that the former detect a strictly larger subset of entangled states than the latter. Whether linear or nonlinear, the method is measurement-device dependent, so that imperfect measurements may cause false certification of entanglement in a shared state. Measurement-device-independent entanglement witnesses provide an escape from such measurement dependence of the entanglement detection for linear entanglement witnesses. We presented measurement-device-independent nonlinear entanglement witnesses for non-positive partial transpose entangled states as well as for bound entangled states with positive partial transpose. The constructed measurement-device-independent nonlinear entanglement witnesses certified the entanglement of the same sets of entangled states as their device-dependent parents do, and therefore are better than the linear entanglement witnesses, device-independent or otherwise.

### Publications:

1. Riddhi Ghosh, Ahana Ghoshal, and Ujjwal Sen, *Quantum thermal transistors: Operation characteristics in steady state versus transient regimes*, *Phys. Rev. A* **103**, 052613, (2021).
2. Chirag Srivastava, Sreetama Das, and Ujjwal Sen, *Resource theory of quantum coherence with probabilistically non-distinguishable pointers and corresponding wave-particle duality*, *Phys. Rev. A* **103**, 022417 (2021).
3. Kornikar Sen, Chirag Srivastava, Shiladitya Mal, Aditi Sen De, and Ujjwal Sen, *Detection loophole in measurement-device-independent entanglement witness*, *Phys. Rev. A* **103**, 032415 (2021).

4. Debmalya Das and Ujjwal Sen, *Delayed choice of paths selected by grin and snarl of quantum Cheshire Cat*, *Phys. Rev. A* **103**, 012228 (2021).
5. Chirag Srivastava, Shiladitya Mal, Aditi Sen De, and Ujjwal Sen, *Sequential measurement-device-independent entanglement detection by multiple observers*, *Phys. Rev. A* **103**, 032408 (2021).
6. Sohail and Ujjwal Sen, *Witnessing nonseparability of bipartite quantum operations*, *Phys. Lett. A* **404**, 127411 (2021).
7. Sreetama Das, Asutosh Kumar, Aditi Sen De, and Ujjwal Sen, *Quantum Process Randomness*, *Phys. Lett. A* **387**, 127024 (2021).
8. Ahana Ghoshal, Sreetama Das, Aditi Sen De, and Ujjwal Sen, *Population inversion and entanglement in single and double glassy Jaynes-Cummings models*, *Phys. Rev. A* **101**, 053805 (2020).
9. Chirag Srivastava, Sreetama Das, Aditi Sen De, and Ujjwal Sen, *Signaling versus distinguishing different superpositions of same pure quantum state*, *J. Phys. A: Math. Theor.* **53**, 275302 (2020).
10. Stav Haldar, Saptarshi Roy, Titas Chanda, Aditi Sen De, and Ujjwal Sen, *Multipartite entanglement at dynamical quantum phase transitions with non-uniformly spaced criticalities*, *Phys. Rev. B* **101**, 224304 (2020).
11. Saptarshi Roy, Tamoghna Das, Debmalya Das, Aditi Sen De, and Ujjwal Sen, *How efficient is transport of quantum cargo through multiple highways?*, *Annals of Physics* **422**, 168281 (2020).
12. Sreetama Das, Chiranjib Mukhopadhyay, Sudipto Singha Roy, Samyadeb Bhattacharya, Aditi Sen De, and Ujjwal Sen, *Wave-particle duality employing quantum coherence in superposition with non-orthogonal pointers*, *J. Phys. A: Math. Theor.* **53**, 115301 (2020).

## Preprints:

1. Kornikar Sen, Chirag Srivastava, and Ujjwal Sen, *Measurement-device-independent nonlinear entanglement witnesses*, arXiv:2106.05796.
2. George Biswas, Anindya Biswas, and Ujjwal Sen, *Inhibition of spread of typical bipartite and genuine multiparty entanglement in response to quenched disorder*, arXiv:2105.03384.
3. Brij Mohan, Sohail, Chirag Srivastava, Arun K. Pati, and Ujjwal Sen, *Quantum information can remain without physical body in volatile form*, arXiv:2105.03250.
4. Ujjwal Sen, *Quantum analog of resource theory of stinginess*, arXiv:2103.16799.
5. Saronath Halder and Ujjwal Sen, *Unextendible entangled bases and more nonlocality with less entanglement*, arXiv:2103.09140.

6. Ahana Ghoshal and Ujjwal Sen, *Heat current and entropy production rate in local non-Markovian quantum dynamics of global Markovian evolution*, arXiv:2102.06694.
7. Kornikar Sen, Chirag Srivastava, Shiladitya Mal, Aditi Sen De, and Ujjwal Sen, *Noisy quantum input loophole in measurement-device-independent entanglement witnesses*, arXiv:2012.09089.
8. Ahana Ghoshal, Sreetama Das, Amit Kumar Pal, Aditi Sen(De), and Ujjwal Sen, *Three cooling off in two baths: Beyond two-body system-bath interactions in quantum refrigerators*, arXiv:2012.08399.
9. Chirag Srivastava and Ujjwal Sen, *Scaling of non-adiabaticity in disordered quench of quantum Rabi model close to phase transition*, arXiv:2012.04568.
10. Arun Sehrawat, Chirag Srivastava, and Ujjwal Sen, *Equilibrium and dynamical phase transitions in fully connected quantum Ising model: Approximate energy eigenstates and critical time*, arXiv:2012.00561.
11. Asmitha Mekala and Ujjwal Sen, *All entangled states are quantum coherent with locally distinguishable pointers*, arXiv:2008.11148.
12. Shashaank Khanna, Saronath Halder, and Ujjwal Sen, *Quantum entanglement percolation on monolayer honeycomb lattice*, arXiv:2008.09040.
13. Saronath Halder and Ujjwal Sen, *Local indistinguishability and incompleteness of entangled orthogonal bases: Method to generate two-element locally indistinguishable ensembles*, arXiv:2008.01620.
14. Asmita Kumari and Ujjwal Sen, *Local preservation of no-signaling in multiparty PT-symmetric evolutions*, arXiv:2007.13461.
15. C S Sudheer Kumar and Ujjwal Sen, *How many runs ensure quantum fidelity in teleportation experiment?*, arXiv:2004.14816.
16. Tanaya Ray, Arun Kumar Pati, and Ujjwal Sen, *Estimating quantum coherence by noncommutativity of any observable and its incoherent part*, arXiv:2004.07729.
17. Shubhalakshmi S and Ujjwal Sen, *Noncommutative coherence and quantum phase estimation algorithm*, arXiv:2004.01419.

### Conference/Workshops Attended:

1. QMAT-2020, SN Bose National Center for Basic Sciences, Kolkata, India, 07-11 Sep, 2020. Online.
2. Young Quantum 2020, Harish-Chandra Research Institute, Allahabad, India, 12-15 Oct, 2020. Online.



## Invited Lectures/Seminars:

1. *Quantum talks*, IIT Hyderabad, India, June-July 2020. Online. Presented a talk on “Quantum devices using systems with impurities”.
2. *International E-Conference on Recent Advances in Physics*, GPGC, Bazpur, India, 24-25 Jun, 2020. Online. Presented a talk on “Quantum devices using systems with impurities”.
3. *Physics Colloquium*, IIT Gandhinagar, India, 03 July 2020. Online. Presented a talk on “Quantum devices using systems with impurities”.
4. *QMAT-2020*, SN Bose National Center for Basic Sciences, Kolkata, India, 07-11 Sep, 2020. Online. Presented a talk on “Quantum devices in disordered systems”.
5. *India-Russia Quantum Technologies Meet*, Embassy of India in Russia and the DST, GoI, 10 Sep, 2020. Online. Presented a talk on “Quantum information meets few- and many-body physics”.
6. *Technical Education Quality Improvement Programme (TEQIP) - III sponsored Faculty development program (FDP) on Quantum Information and Computation*, NIT Sikkim, India, 03-17 Oct, 2020. Online. Presented two talks on “Interface of quantum information with few- and many-body physics”.

## Other Activities:

1. Current PhD students: Chirag Srivastava, Ahana Ghoshal, Kornikar Sen, Tanaya Ray. [Sreetama Das, another student, was awarded a PhD degree recently.]
2. Courses taken/ongoing: Research methodology and Numerical Methods, January-May 2020 (shared with Prof. Santosh K. Rai); Quantum information and computation 2, January-May 2020 (shared with Prof. Aditi Sen De); Quantum Information and Computation 1, August-December 2020 (shared with Profs. Arun Kumar Pati and Aditi Sen De); Quantum Information and Computation 2, January-May 2021 (shared with Prof. Aditi Sen De); Quantum mechanics 2, May-August 2021.
3. Committees: Convener of HRI computer committee, members of HRI cluster computing, HRI outreach program, HRI faculty appointment committees.
4. Mentored/mentoring projects of Aparajita Bhattacharyya, Priya Ghosh, Sayan Mondal, Tanay Konar, Anish Majumdar.
5. Mentored/mentoring the masters theses of Ingita Banerjee, IIT Dhanbad; Sheikh Parvez Mandal, IISER Pune; Soubhadra Maiti, IISER Pune. Online.
6. Visiting students (online): Sheikh Parvez Mandal, Ayushi Dubal, Riddhi Ghosh, Sayanwita Biswas, Ingita Banerjee, Kartikeya Arora, Soham Sau, Shilpa Mahato, Soubhadra Maiti, Adithi Ajith, Swati Choudhary, Arunava Majumdar, Sudheer Kumar.