Academic Report (2022-23)

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Research Summary:

My broad areas of research are astrophysics, general relativity, and dynamical systems. For last one year, I have been working on black hole accretion, emergent gravity phenomena, theory of traversable wormholes, and application of the theory of dynamical systems in large scale fluid flow under strong gravity. With one of my Ph.D. students and external collaborators, I have started exploring the emergence of nonlinearity and chaotic traits of the dynamics of axially symmetric flow around black holes, and its signatures as revealed in the observed spectra.

I, along with my Ph.D. students and my post doctoral fellows, made two important contributions through our works published in the last one year, which are as follows:

In a set of two papers published in the Physical Review D Letters (Erstwhile Physical Review D Rapid Communication) and Physical Review D, we have demonstrated that an emergent space time can be obtained through nonlinear perturbation of arbitrary order of a transonic flow. As of now, every single work in the literature (on analogue gravity phenomena) constructs the black hole like analogue space time within flowing fluid by linearly perturbing the flow. We have explicitly demonstrated that such analogue space time can be produced even for nonlinear perturbation of higher orders. This proves that the emergent gravity phenomena is not an artifact of the linear perturbation process, rather it has a much deeper physical significance compared to what had been believed in the literature before our works. Our works in this direction have attracted attention in the community and has been highlighted by Nature (journal). One can go through the article published in Nature highlighting our works, the corresponding article, titled 'Model shows how to create a black hole in a lab', was published as a Nature highlights in the journal Nature on 29th of August, 2022. The corresponding URL of the article is

https://www.nature.com/articles/d44151-022-00093-7

In another series of published works, we have demonstrated, for the first time in the literature as we believe, how identify and classify the horizons in the emergent space time using the analogue Carter-Penrose diagrams. For the first time the construction of the compactified Causal structures have been used for study of analog spacetime embedded within a natural large scale fluid flow under the influence of strong gravity. Such works will be helpful in future to understand the natures of the analogue black hole horizons in various emergent gravity systems, as we believe.

In addition to the aforementioned works, we have devised an elegant technique which enables one to estimate, completely analytically (without any numerical computation) the multi transonic properties and the nature of related bifurcation phenomena for matter flow in accretion disc around non-spinning black holes.

We have also started working on astrophysical jets in connection to certain type of AGNs, and on traversable acoustic wormholes, which will be reported in the next academic report.

Publications:

1. Mitra, Arpan Krishna., Chakraborty, Aishee., Tarafder, Pratik., & Das, Tapas K., *Multi-criticality and related bifurcation in accretion discs around non-rotating black holes – an analytical study*, General Relativity and Gravitation, **Volume 54, Issue 11, article id.149**, November, **(2022)**.

2. Maity, Susovan.,Shaikh, Md. Arif., Tarafdar, Pratik., & Das, Tapas K., *Carter-Penrose diagrams for emergent spacetime in axisymmetrically accreting black hole systems*, Physical Review D, **Volume 106, Issue 4, article id.044062**, August, **(2022)**.

3. Fernandes, Karan., Maity, Susovan., & Das, Tapas K., *Dynamical spacetimes from nonlinear perturbations*, Physical Review D Letters, **Volume 106, Issue 2, article id.L021701**, July, **(2022)**.

4. Fernandes, Karan., Maity, Susovan., & Das, Tapas K., *Dynamical analogue spacetimes in non-relativistic flows*, Physical Review D, **Volume 106, Issue 2, article id.025020**, July, **(2022)**.

Preprints:

1. Maity, Susovan.,Shaikh, Md. Arif., Tarafdar, Pratik., Ghose, Souvik, & Das, Tapas K., *Influence of the flow thickness on acoustic surface gravity for accreting black holes*, Physical Review D, **Under Review**, Manuscript Number DC13575, **(Submitted on 27th of March, 2022)**

Conference/Workshops Attended:

1. *Exploring The Cosmos 2023: A National Seminar on Relativistic Universe*, organized by, and at took place at High Energy & Cosmic Ray Research Centre University of North Bengal, during the period

Visits to other Institutes:

1. Surendranath College, University of Calcutta, September 2022.
2. Bhairab Ganguly College, West Bengal State University, January, 2023.
3. Lady Brabourne College, University of Calcutta, February, 2023.
4. High Energy & Cosmic Ray Research Centre, University of North Bengal, February, 2023.
5. Visva-bharati University, Santiniketan, March 2023.
6. Physics and Applied Mathematics Unit, Indian Statistical Institute, Kolkata (several times).
7. Ramakrishna Mission Vivekananda Centenary College, Kolkata (several times).
8. St. Xavier's College, Kolkata (several times).