Declaration

I, ***Mr. Pankaj Sarma*** *(Roll No. PHP19103 and Registration No. TZ167143 of 2016, Department of Physics, School of Sciences, Tezpur University) hereby declare that the thesis entitled, "****ASTROPHYSICAL FLUID STRUCTURIZATION IN DIVERSE SOLAR ENVIRONS****", submitted in partial fulfilment of the requirements for the award of the degree of* ***Doctor of Philosophy (PhD) in Physics****, is a genuine record of original research work carried out by me during my academic period. Any texts, figures, theories, data or results that are not of my own, which are properly used herein, are appropriately and honestly referenced in order to give due credit to the original creator(s) and author(s). I further state that the entire thesis has been prepared by me solely as per my basic astro-fluid concepts and skills professionally developed till now.*

I also hereby declare that neither this work as a whole nor a part of it has been submitted to any other university, academic institution or organization for any degree, diploma, fellowship, or any other similar title or recognition.

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Certificate

*This is to certify that the thesis entitled, "***ASTROPHYSICAL FLUID STRUCTURIZATION IN DIVERSE SOLAR ENVIRONS***", submitted to the School of Sciences, Tezpur University, in partial fulfilment of the requirements for the award of the degree of Doctor of Philosophy (PhD) in Physics is a genuine record of original research investigations carried out by* ***Mr. Pankaj Sarma*** *(Roll No. PHP19103 and Registration No. TZ167143 of 2016) under my constant academic supervision.*

All the helps, supports, and cooperation received by him throughout this academic journey from various sources have been thankfully recognized and acknowledged. The entire thesis has been prepared and compiled by him solely as per his thematic conceptions and experiences professionally developed so far under my continuous academic directions and observations.

It is further stated hereby that no part of the contents compiled in this thesis has been submitted elsewhere for the award of any degree, diploma, or recognition.

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List of abbreviations

S. No.	*Abbreviation*	*Full form*
1	*ISM*	*Interstellar Medium*
2	*IGM*	*Intergalactic Medium*
3	*ICM*	*Intracluster medium*
4	*GES*	*Gravito-Electrostatic Sheath*
5	*SIP*	*Solar Interior Plasma*
6	*SWP*	*Solar Wind Plasma*
7	*SSB*	*Solar Surface Boundary*
8	*SSM*	*Standard Solar Model*
9	*SW*	*Solar Wind*
10	*RK-IV*	*Fourth-order Runge-Kutta*
11	*PSP*	*Parker Solar Probe*
12	*HIS*	*Heavy Ion Sensor*
13	*SolO*	*Solar Orbiter*
14	*au*	*Astronomical Unit*

<u>***List of symbols and significances***</u>

Symbols and their significances for the Chapter-2, Chapter-3, and Chapter-4:

S. No.	*Symbol*	*Significance*
1	r, ξ	*Radial distance, normalized radial distance respectively*
2	t	*Time coordinate*
3	$n_{e(i)}$, n_o, $N_{e(i)}$	*Electron (ion) number density, mean SIP equilibrium number density, normalized electron (ion) population density respectively*
4	e	*Magnitude of the electronic (ionic) charge*
5	k_B	*Boltzmann constant,* $k_B=1.38\times10^{-23}$ *J* K^{-1}.
6	$T_{e(i)}$, $T^*_{e(i)}$, T_o	*Electron (ion) temperature, normalized electron (ion) temperature, SIP core temperature respectively*
7	v	*Local ion flow speed*
8	λ_J	*Jeans length*
9	M	*Mach number*
10	c_s	*Speed of sound in the SIP*
11	$m_{e(i)}$	*Mass of an electron (ion)*
12	P_T, P^*_T, P_0, P_{Th}	*Total pressure in a considered region, normalized pressure, mean SIP pressure, bulk plasma thermal pressure respectively*
13	η	*Shear viscosity coefficient of the SIP fluid*
14	B	*Effective magnetic field responsible for the magnetic pressure*
15	μ_0	*Vacuum permeability*
16	ε_0	*Vacuum permittivity*
17	G	*Newtonian universal gravitational constant,* $G=6.67\times10^{-11}$ *N* m^2 kg^{-2}
18	ϕ, Φ	*Electric potential, normalized electric potential respectively*
19	ψ, Ψ	*Gravitational potential, normalized gravitational potential respectively*
20	$j_{SIP(SWP)}$, $J_{SIP(SWP)}$, J_B	*SIP (SWP) electric current density, Normalized SIP (SWP) electric current density, SIP Bohm current density strength respectively*
21	u	*Bohm velocity*
22	λ_{De}	*Solar electron Debye length*

Symbols and their significances for the Chapter-5 and Chapter-6:

S. No.	*Symbol*	*Significance*
1	r, ξ	*Radial distance, normalized radial distance respectively*
2	t	*Time coordinate*
3	n_e, n_{e0}, N_e	*Electron number density, equilibrium electron number density, normalized electron number density respectively*
4	$n_{+(-)}, n_{+(-)0}, N_{+(-)}$	*Positive (negative) ion number density, equilibrium positive (negative) ion number density, normalized positive (negative) ion number density respectively*
5	n_0	*Equilibrium (mean) solar plasma density*
6	e	*Electronic (protonic) charge unit*
7	k_B	*Boltzmann constant*
8	T_e	*Electron temperature*
9	$T_{+(-)}$	*Positive (negative) ion temperature*
10	$v_{+(-)}$	*Positive (negative) ion velocity*
11	λ_J	*Jeans scale length*
12	$M_{+(-)}$	*Mach number for positive (negative) ion*
13	c_s	*Speed of sound in the SIP*
14	m_e	*Electron mass*
15	$m_{+(-)}$	*Positive (negative) ion mass*
16	$P_{T+(-)}, P_T, P^*_{T+(-)}, P_0$	*Positive (negative) ion partial pressure, total pressure, normalized positive (negative) ion partial pressure, mean SIP pressure respectively*
17	ε_0	*Vacuum permittivity*
18	G	*Universal gravitational constant*
19	ϕ, Φ	*Electric potential, normalized electric potential respectively*
20	ψ, Ψ	*Gravitational potential, normalized gravitational potential respectively*
21	$j_{SIP(SWP)}, J_{SIP(SWP)}, J_B$	*SIP (SWP) current density, normalized SIP (SWP) current density, SIP Bohm current density strength respectively*
22	$u_{+(-)}$	*Bohm velocity*
23	λ_{De}	*Solar electron Debye length*

Academic program presentation

(A). Oral presentation:

1. **Pankaj Sarma**, P. K. Karmakar, "A theoretic investigation of nonlinear structure formation dynamics in non-ideal protoplanetary disks", ***North East Meet of Astronomers (NEMA-V)***, Tezpur University, India, 11–13 September, 2019.

2. **Pankaj Sarma**, P. K. Karmakar, "Nonlinear structure formation in non-ideal protoplanetary disks", ***International Conference on Plasma Theory and Simulations (PTS-2020)***, Guru Ghasidas Central University, Department of Physics, Bilaspur, India, 14-15 September, 2020.

(B). Poster presentation:

3. **Pankaj Sarma**, P. K. Karmakar, "Nonlinear dynamics of structure formation in non-ideal protoplanetary disks", ***12th International Conference on Plasma Science and Applications (ICPSA-2019)***, University of Lucknow, India, 11-14 November, 2019.

4. **Pankaj Sarma**, P. K. Karmakar, "A gravito-electrostatic sheath model of non-thermal turbulent solar plasmas with κ-modified polytropic equation of state", ***National Topical Conference on "Chandra's Contribution in Plasma Astrophysics"***, School of Physical Sciences, Jawaharlal Nehru University, New Delhi, India, 19-20 October, 2021.

5. **Pankaj Sarma**, P. K. Karmakar, "Analysis of non-thermal solar plasmas in κ-modified polytropic GES model framework", ***21st National Space Science Symposium (NSSS-2022)***, Indian Institute of Science Education and Research (IISER), Kolkata, West Bengal, India, 31 January - 4 February, 2022.

6. **Pankaj Sarma**, P. K. Karmakar, "Equilibrium structure of the magneto-active solar plasmas in the κ-modified gravito-electrostatic sheath model fabric", ***European Astronomical Society Annual Meeting (EAS)-2022***, Valencia Conference Centre, Valencia, Spain, 27 June – 1 July, 2022.

List of research publications

International refereed journal of repute:

1. **Sarma, P.** and Karmakar, P. K. **Nonlinear dynamics of structure formation in protoplanetary disks**. *Chinese Journal of Physics (CJP)*, 74:9-19, 2021.

2. **Sarma, P.** and Karmakar, P. K. **Analyzing non-thermal steady solar plasmas in the *κ*-modified polytropic GES model framework**. *Journal of Astrophysics and Astronomy (JOAA)*, 43:46(1)-46(7), 2022.

3. **Sarma, P.** and Karmakar, P. K. **Solar plasma characterization in Kappa (*κ*)-modified polytropic turbomagnetic GES-model perspective**. *Monthly Notices of the Royal Astronomical Society (MNRAS)*, 519(2):2879-2916, 2023.

4. **Sarma, P.** and Karmakar, P. K. **Effects of negative ions on equilibrium solar plasmas in the fabric of gravito-electrostatic sheath model**. *Scientific Reports (SREP, Nature Portfolio)*, 2023 (in review).