Project name, IRN	**AP19677351** –Studying the formation of star clusters with combined magnetohydrodynamics and N-body simulations
Completion date	25.07.2023-31.12.2025
Project supervisor	Shukirgaliev Bekdaulet,, PhD
Report	Star formation remains one of the most complex and computationally expensive physical processes, even with modern numerical techniques and supercomputers. Most recent studies started to self-consistently combine the magnetohydrodynamics (MHD) of star-forming gas with the N-body dynamics of the newly formed stars to study star formation in great detail. However, this method does not allow for the simulation of star cluster formation in a wide range of parameter space to study systems of star clusters. Therefore, simplified star-formation models and an instantaneous gas expulsion approach have been used by many groups to link the long-term evolution of star clusters to their formation conditions. In this project, we aim to build a bridge between these two approaches by comparing self-consistent MHD and N-body simulations of clusters to equivalent clusters formed with typical simplified, semi-analytical star formation models but then evolve using the full MHD/N-body approach. During the project implementation, we will examine how well the simplified cluster formation models reproduce the results of the more detailed star formation simulations. As a result of the project, we expect to obtain a new model of bound star cluster formation fully connected to the initial gas cloud properties.
Purpose	Studying the formation of star clusters with combined magnetohydrodynamical and N-body simulations considering the comprehensive physics of the stellar feedback-driven gas expulsion.
Expected results	An important objective of our project is to bring young Kazakhstani physicists to a new highly-promising research frontier emerging at the crossroads of astrophysics and computer science. Actively involved students will use the exciting world of astrophysical phenomena to learn how to apply MHD simulations in astrophysical problems becoming essential in industry and present their own accomplishments at local and international schools and conferences. We anticipate obtaining new detailed models of star clusters which can be used for parameter study of the star cluster formation, the long-term evolution, and initial cluster mass function.
Research group	Supervisor Shukirgaliev Bekdaulet, PhD, h-index h=7 (ResearcherID: N-4025-2014 ORCID: 0000-0002-4601-7065 Scopus Author ID: 57163629900). https://www.scopus.com/authid/detail.uri?authorId=57163629900 Kalambai Mukhagali, PhD, h-index h=2 (ResearcherID: AGN-2638-2022 ORCID: 0000-0002-0570-7270 Scopus Author ID: 57224666055). https://www.scopus.com/authid/detail.uri?authorId=57224666055 Asilkhan Adilkhan, Master of Engineering, (ORCID - 0000-0001-6428-00000).

Publications in scientific publications	1. Jafari, N., & Shukirgaliyev, B. Nonrelativistic limits of the Klein-Gordon and Dirac equations in the Amelino-Camelia DSR // Physics Letters B. – 2024. – Vol. 853. – P. 138693. doi: 10.1016/j.physletb.2024.138693 (IF=4.3, Q1, CiteScore Percentile 93) 2. Askar T., Yergaliyev A., Shukirgaliyev B., Abdikamalov E. Exploring Numba and CuPy for GPU-Accelerated Monte Carlo Radiation Transport // Computation. – 2024. – Vol. 12. – Issue 3. – P. 61. DOI: 10.3390/computation12030061 (IF=1.9, Q2, CiteScore Percentile 71)