Tapas Baug

Assistant Professor

Astrophysics & Cosmology

tapasbaug@bose.res.in

Guidance of Students/Post-Docs/Scientists

a) Post-Docs

1. Piyali Saha; Observational study of Galactic star formation

b) External Project Students / Summer Training

1. Aashique Unikrishnan; Characterization of a few Star-forming Filaments National Institute of Technology, Calicut
2. Swagata Bera; Distances of a sample of Mira variables using two methods and their comparison; Visva Bharati University, Shantiniketan

Areas of Research

Galactic massive star formation, Circumstellar dust shell of post-main sequence stars, Astronomical Instrumentation

The physical process that governs the formation of a massive star (> 8 solar mass) is an unsolved problem in astrophysics. It is still doubted whether the formation mechanism of a massive star is a scaled-up version that produces low-mass stars or if it is a fundamentally different process. The observational study of pre-main sequence phases of massive star formation are elusive because massive stars are relatively rare, have a quick pre-main sequence evolution and nucleosynthesis in their core begins before they come out of the optically thick parent molecular envelope. Two basic sets of theories are available in the literature describing the core-scale (<0.01 pc) formation mechanisms of massive stars. One class of theories propose that massive stars form within the massive prestellar cores in a similar manner that forms their low-mass counterpart (i.e., `core accretion' model). Other theories tend to believe that massive stars form in completely different mechanisms such as competitive clump-scale accretion (i.e., `competitive accretion' model).

In recent years, two other large-scale (pc-scale) theories have gained considerable observational evidence. One of them is the collision between two nearby molecular clouds, followed by strong shock compression of gas, that is capable to give the sufficient accretion rate to form massive stars. Evidence of such cloud-cloud collision is also found observationally (see Baug et al., 2016). Another potential theory for the formation of a massive star is accretion through filaments. Filamentary structures identified in Galactic molecular clouds have the ability to form both low-mass and massive stars. Observationally, the formation of massive stars at the junction of multiple filaments is found in several Galactic star-forming regions (see e.g., Baug et al., 2015; Baug et al., 2018).

After the advent of Herschel observations, filaments are found to be ubiquitous in Galactic star-forming clouds. These filaments are believed to aid star-formation by channeling gas along their long-axes. However, a direct implication of accretion through filaments would be identifying a direct correlation between the protostellar accretion and gas flow along the filaments. But direct detection of accreting gas at the core scale is difficult because of complicated gas dynamics at that scale. A solution to this problem could be finding a correlation of the protostellar jets or bipolar outflows associated with the filamentary structures. A general understanding is that these bipolar outflows are launched by the rotating accretion disk of the protostar, and can be used to infer the orientation of the accretion disk. One would, thus, ideally expect a preferred position angle of bipolar outflows with respect to the orientation of the long axis of the filaments. Also, these outflows are much easier to detect compared to accretion disks. Theories predict different orientations of accretion disks (hence, the angular momentum axes) of protostars with respect to filament long-axis (parallel or perpendicular) depending on the physical conditions of the surrounding environment and the strength of magnetic fields.

Previous studies towards the low-mass regions found conflicting results. Some of the studies found an orthogonal outflow-filament orientation, while other studies found a random distribution of outflow-filament orientation in the Perseus molecular cloud. A previous study on a young massive star-forming region found orthogonal orientation of outflows with respect to the host filaments. On the contrary, in a recent study on eleven Galactic massive star-forming regions using Atacama Large millimeter/submillimeter Array (ALMA) data we found no correlation of outflow axis with the orientation of filaments or even with the large-scale magnetic field direction (Baug et al., 2020). Figure 1 shows the cumulative distribution of the plane of sky position angles (gamma_Fil) between the outflow axes and the orientations of the host filaments. The cumulative distribution resembles more to the random distribution generated using Monte-Carlo simulations (see Baug et al. 2020 for more details).

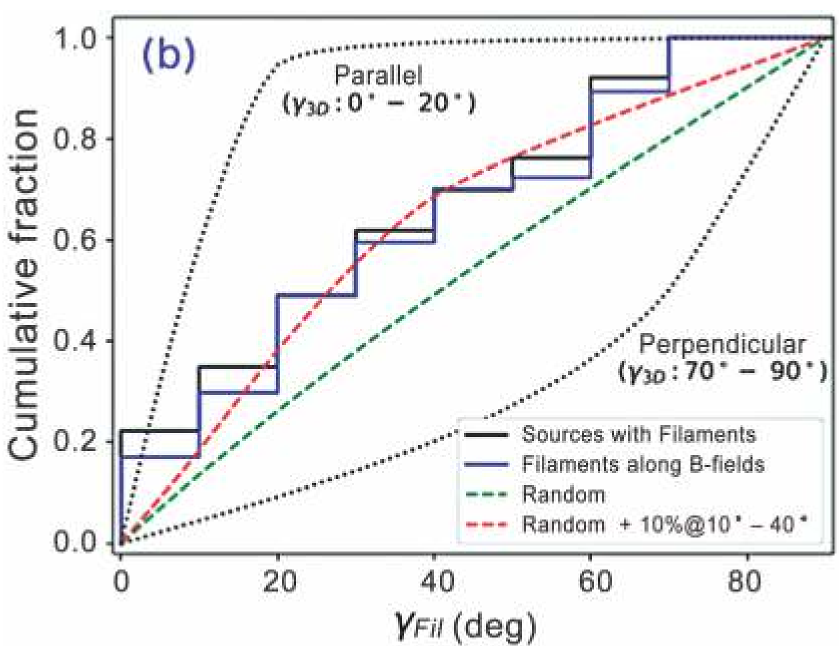

Figure 1. Cumulative histogram function of the projected plane of sky position angles between the directions of outflows and position angles of filaments (gamma_Fil). The Green dashed line marks a theoretical cumulative distribution function if the outflow directions are purely random.

Plan of Future Work Including Project

1. S. N. Bose National Centre for Basic Sciences took the initiative to build the first astronomical observation facility in the Eastern part of India. The plan is to set up a 1.5-m telescope at Panchet hill (23.6286 N, 86.7668 E), Purulia district of West Bengal. The primary aims of this telescope project are – (1) for cutting-edge scientific observations, (2) to train younger researchers and students in observational astronomy, and (3) to fill the longitudinal gap for uninterrupted monitoring of any astronomical event in the optical/Infrared wavelength regime. I am involved in this project as an Executive team member. We have already submitted a proposal for funding of this project to Department of Science and Technology, Govt. of India.

2. I am involved in several projects on massive star formation using the data from Atacama Large Millimeter/submillimeter Array (ALMA). The unprecedented sensitivity and resolution of ALMA data help us to resolve the finer details of the Galactic star-forming regions, and thus, the detailed physical mechanisms. I am involved in ALMA projects along with several national and international collaborators. In future, I would like to pursue research on Galactic massive star formation using the observations from ALMA and several other national telescopes (e.g., Giant Metrewave Radio Telescope; 3.6-m Devasthal Optical Telescope; 2-m Himalayan Chandra Telescope, etc).