Undergraduate Thesis Prospectus

Shock-Ionized Jets from Massive Protostars

(technical research project in Engineering Science)

Texas's Strategic Early Abortion Ban

(sociotechnical research project)

by

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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General Research Problem

How can a process which cannot be observed, be understood?

Many processes studied in technical fields cannot be directly observed. It is impossible to view the largest scales in astronomy, the smallest scales in particle physics, or events concealed by nature. Instead, we must rely upon modeling, theory, and extrapolation. Sukhanov and Golubjeva investigate how Einstein did this, using concepts of geometry and thermodynamics that need not be "related to any specific, individual physical models." These concepts allowed him to develop special relativity, general relativity, and unified field theory, to describe "the physical picture of the world," both observable and otherwise (2006).

Metaphysical processes can be similarly impossible to observe. Kurjak et al. assert that "a synthesis between scientific data and hypothesis, philosophical thought, and issues of humanities" is necessary "to deal with ethical, juridical, and social problems" like the beginning of human life (2009). For example, in court case *Roe* v *Wade*, the Supreme Court declared that "a fetus is not to be classed as a person" (Dalton, 2006). The Texas GOP, however, claims "life begins at conception" (Dorazio, 2020). This contradiction results directly from the ambiguity of how human life begins; it is compounded by divergent social and religious values, and by political commitments. Thus, in a social context, policy makers and shapers must also develop some means of understanding these unobservable processes.

Shock-ionized jets from massive protostars

What underlying processes govern the way massive protostars form and emit light?

The project is a senior thesis research project advised by Jonathan Tan in the Astronomy Department, as well as Jan Staff (UVI professor), and Jon Ramsey (UVA postdoc).

It is difficult to study how massive stars form, but the protostellar outflows are easier to observe. I conduct post-processing on massive protostellar outflow simulations to algorithmically model shocks in the simulation jets, and predict the corresponding light emissions. The current goal is to process a newer version of the simulation and publish our cumulative results. We are constrained by supercomputer access and run time.

Our research builds upon Staff et al.'s "3D magnetohydrodynamic (MHD) simulations of the outflow-core interaction" using the ZEUS-MP code (2019). As in those simulations, we use the Turbulent Core Model, which is a leading model for how massive stars form via Core Accretion, competing with the Competitive Accretion Model, among other formation scenarios (Staff et al., 2019). ZEUS-MP is now superseded by the state-of-the-art 3D general relativistic MHD code, ATHENA++, to which we are transitioning (Stone et al., 2020).

I conduct post-processing on snapshot data from the simulation, converted to `numpy` array format. Using python, I (1) algorithmically model shocks by calculating shock velocities, temperatures, and ionization, (2) predict the Bremsstrahlung emissions by calculating absorption, emission, and optical depth to (3) create intensity maps (fig. 1) and plot spectra (fig. 2) with `matplotlib`, (4) conduct statistical analysis on flux measurements to predict variability, and (5) compare my results to published observations.

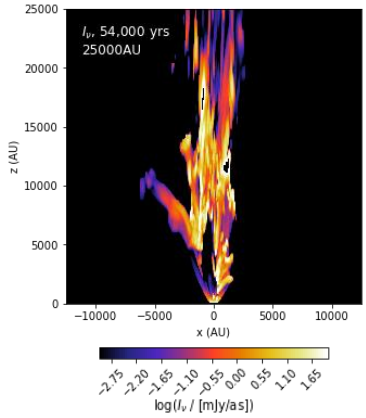

Fig. 1 5.3 GHz Intensity from Bremsstrahlung Emission of a 12M$_\odot$ simulated outflow snapshot (author)

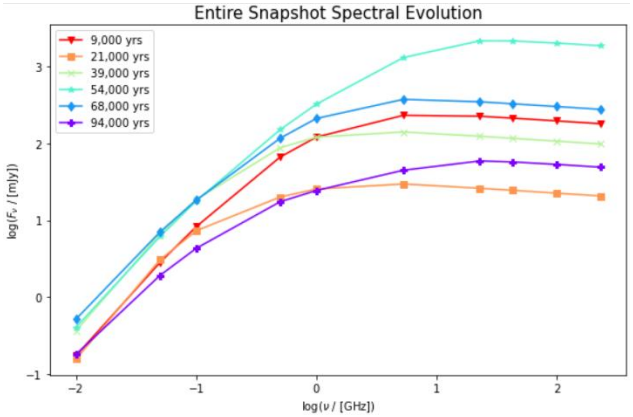

Fig. 2 Spectra resulting from shock-emissions in a simulated outflow over time, growing from 1.5-16M$_\odot$ (author

In concluding this project, we will publish a thorough characterization of the predicted emissions from shock-ionizations in the jets of massive protostars, should they follow the Turbulent Core Model. Success will either mean these results match observations and offer support for out model, to be further investigated, or the results differ from observations, encouraging consideration of other models. Further study is necessary to characterize the emissions resulting from other (non-shock) processes, and update the post-processing for newer simulation versions.

Texas's Strategic Early Abortion Ban

How did anti-abortion Texan politicians and advocates pass the Texas Heartbeat Act?

The Texas Heartbeat Act (SB 8) took effect September 1, 2021. The Act allows citizens to bring a civil suit against anyone who "knowingly engages in conduct that aids or abets the performance or inducement of an abortion" after embryonic cardiac activity is detectable (S. B. No. 8). The success in passing this act, after most early abortion bans have failed, is striking. It exemplifies the "red-state wave of legislation" that Bill

Hutchinson, of ABC News, describes as "deputizing and financially motivating everyday citizens to help enforce laws" (2021).

Researchers have investigated past attempts of "heartbeat bills," including early Ohio House Bill 125, from 2013. Marc Spindelman found that, in accordance with the *Planned Parenthood v. Casey* supreme court decision, H.B. 125 was an "unconstitutional restriction on a woman's pre-viability abortion decision," but may be acceptable when operating post-viability, except in cases "necessary to protect or preserve a pregnant woman's life or health" (2013). Georgia LIFE Act attempted to make "a detectable fetal heartbeat…the new 'viability' standard" (Varunok, 2021), was approved in March 2019, but was ruled unconstitutional in July 2020 (Williams, K., 2020). The Texas Heartbeat Act is different from these past attempts in that it "shall be enforced exclusively through…private civil actions" (S.B. No. 8, 2021). Timing is also pertinent, as researchers have found that the Covid-19 pandemic was "a boon for those opposed to the right to abortion in Texas" (Boyer, 2021).

Participants include the Republican Party of Texas (RPT), anti-abortion advocates like the Texas Right to Life (TRTL) group, Texans desiring access to abortions, pro-choice advocates like Avow, and reproductive healthcare providers. RPT's agenda is to advance their conservative platform, including abolishing abortions (Dorazio, 2020). TRTL is an advocacy "opposing abortion at any point of gestation" (TRTL, 2021). Individuals desiring access to abortions form an unorganized group, but they are loosely represented by pro-choice advocates and reproductive healthcare providers. The former includes Avow, which intends to "secure unrestricted abortion access for every Texan" (Avow, 2021). The latter predominantly includes Planned Parenthood of Greater Texas, a

nonprofit reproductive rights advocacy that provides reproductive and related healthcare services to Texans (PPGT, 2021).

While pro-abortion and anti-abortion groups have been involved in every heartbeat bill dispute, the Texas Heartbeat Bill is unique in authorizing private citizens to sue individuals aiding or abetting an abortion, such as healthcare providers, rideshare drivers, and attorneys (Griffey, 2021). In attempting to find a loophole in the *Roe* v *Wade* decision, this strategy brought in these new participants. The law implicates "drivers for ride-hailing services who drop off or pick up passengers at abortion clinics." Rideshare company, Lyft, responded that "drivers are 'never responsible for monitoring where their riders go or why'" and has pledged to "cover all legal fees for drivers sued under the law" (Williams, J., 2021). Attorney Michelle Tuegel explains that the law also "attempts to block attorneys from performing their duty" when a "client seeks legal advice on abortion" (Griffey, 2021).

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