Polarization of circumstellar bow shocks due to electron scattering

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Motivation

Circumstellar material (CSM) probes stellar mass loss and provides a link between progenitors and interacting supernovae.

- Bow shocks are common CSM configurations.

Fig.1:An illustration of bow shock from www.newscientist.com

- Since a bow shock projects an asymmetrical shape onto the sky, light from the star should become polarized by scattering from free electrons in the shock region.
- We investigate the polarization signatures produced by this effect.

Introduction

A bow shock forms when a star moving more quickly than the speed of sound in the local interstellar medium emits a stellar wind that drives a shock wave into the ISM.

- The shock region has a high density of ionized gas that can polarize light via electron scattering.
- Bow shocks may be detectable with polarimetric observations even if the system is unresolved.
- These polarization signatures can constrain stellar wind speeds, stellar motions, and ISM properties in faraway systems. They may also be identifiable in interacting supernovae, helping to connect them with massive progenitors.

Methods

We use Monte Carlo based radiative transfer code *SLIP* to do simulations of our model. *SLIP* is based on the method of Whitney (2011, BASI, 39, 101).
It tracks photons from a central sources as they scatter and become polarized in a user-defined CSM region.

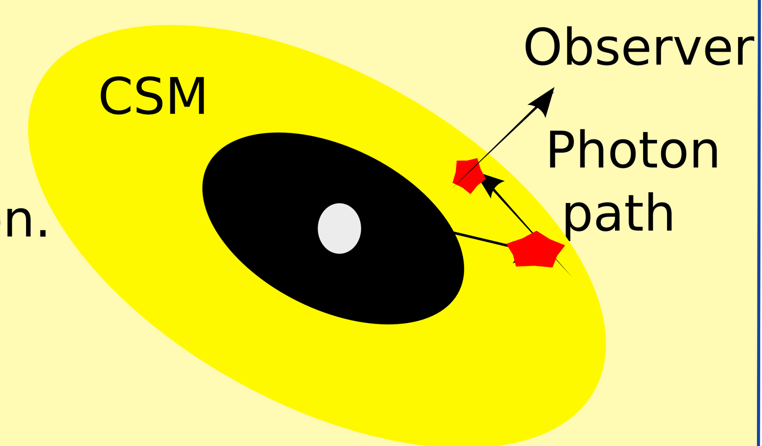

Fig.2: Schematic path of photon through *SLIP*.

- In this code we can vary different parameters of CSM such as temperature, shape, optical depth, viewing angle.
- For the bow shock geometry, we use an analytic model given by Wilkin (1996, ApJ, 459, L31).
- We are trying to make the thickness of one grid shell for CSM.

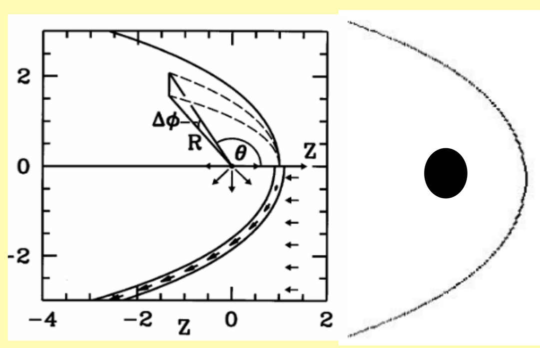

Fig3 (left):thin shell bow shock model Wilkin et. al, (right):Density map of bow shock using *SLIP*

Results

Color bar from 0% to 100%

0% 17% 33% 50% 67% 83% 100%

viewing angle	10,000k	20,000k	30,000k
θ=0°			
θ=45°			
θ=90°			
θ=120°			

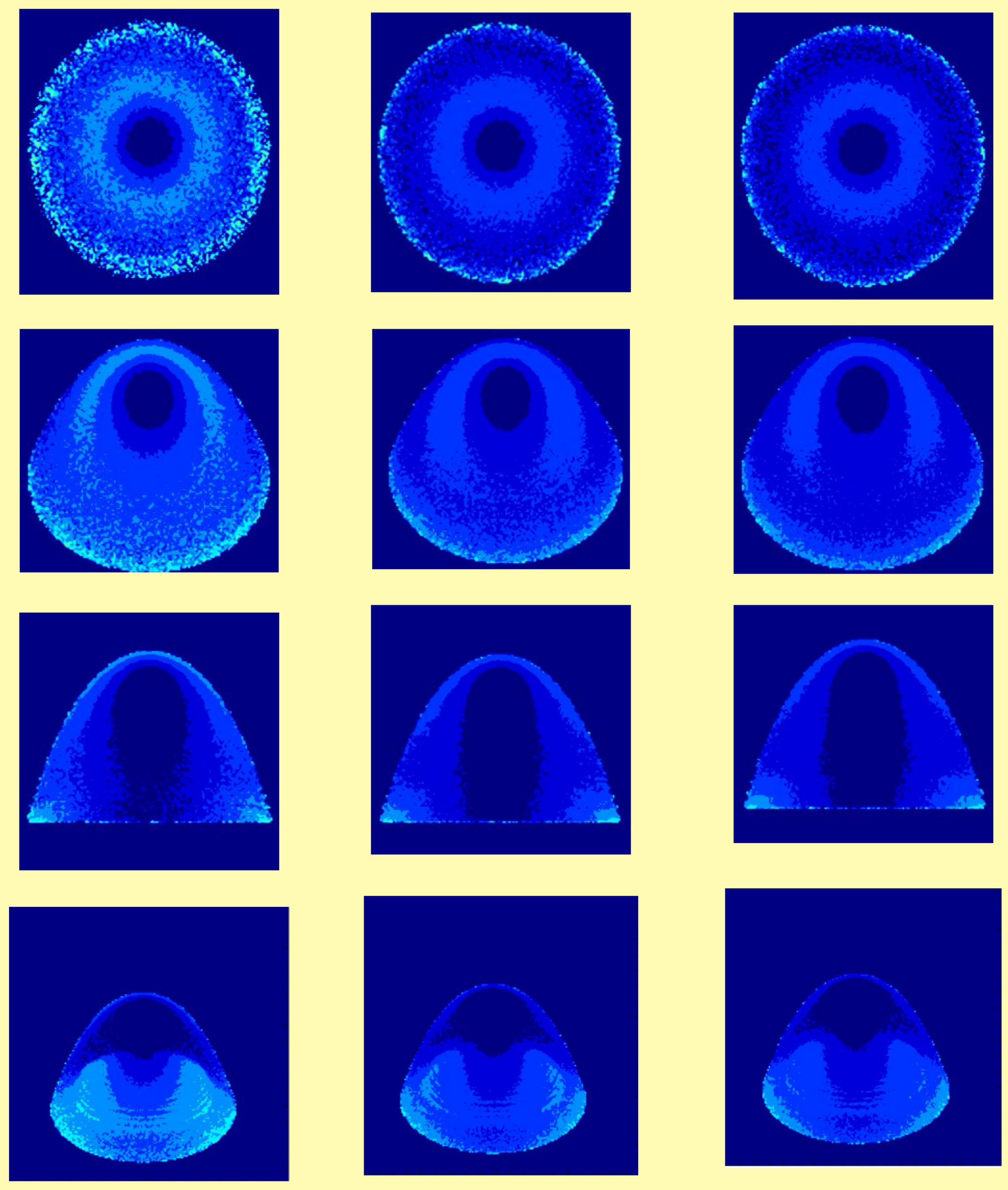

Fig.5(Above) Comparison of polarization maps for different viewing angles and temperature with other parameters constant

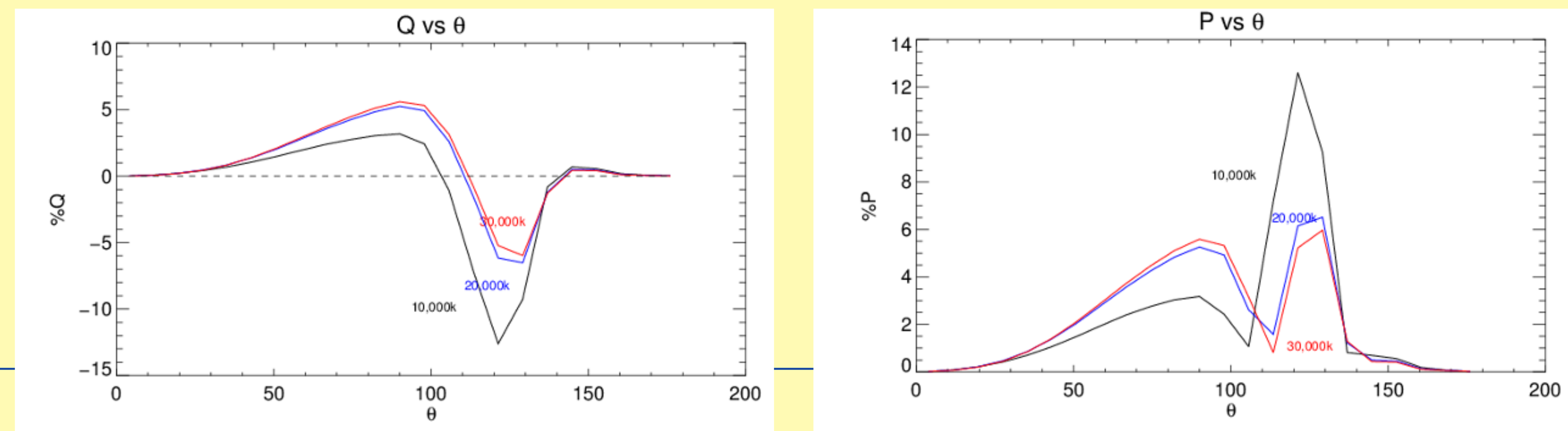

Fig.6(Left) Variation of %Q polarization for different temperature with respect to viewing angle. .(Right) variation of plane polarization for different temperature with respect to viewing angle.

Discussion and Conclusion

- Pattern of percentage polarization changes as we change viewing angle, so imaging polarization could help constrain a bow shock's orientation.
- %P and %Q decreases or increases with temperature depending on viewing angle. The sign of %Q could be used to constrain orientation in the unresolved case.
- Polarization increases towards the edge of the bow shock, probably due to edge effects in the model.

Future Work

- We plan to compare polarization of bow shock with other CSM geometries.
- We will experiment with a gradual density decrease instead of a sharp cut off, to minimize edge effects.
- We plan to do dust polarization using *SLIP* and compare with Neilson's model.

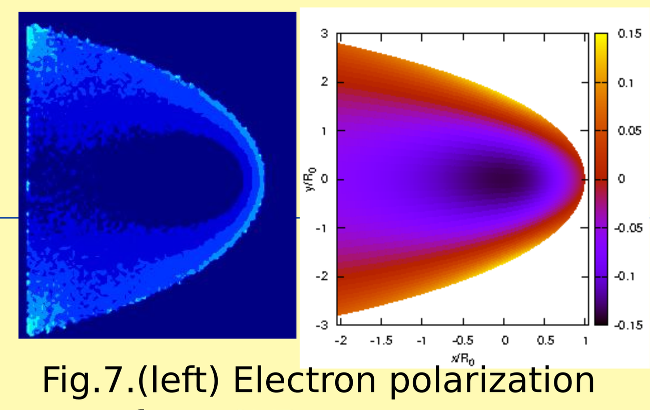

Fig.7.(left) Electron polarization map from *SLIP*
(Right) Dust polarization map from Neilson et, al 2013

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