Design of Experiments Relevant to Accreting Stream-Disk
Impact in Interacting Binaries

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Abstract

In many Cataclysmic Binary systems, mass transfer via Roche lobe overflow onto an accretion disk occurs. This produces a hot spot from the heating created by the supersonic impact of the infalling flow with the rotating accretion disk, which can produce a radiative reverse shock in the infalling flow. This collision region has many ambiguities as a radiation hydrodynamic system. Depending upon conditions, it has been argued (Armitage & Livio, ApJL 493, 888) that the shocked region may be optically thin, thick, or intermediate, which has the potential to significantly alter its structure and emissions. Laboratory experiments have yet to produce colliding flows that create a radiative reverse shock or to produce obliquely incident colliding flows, both of which are aspects of these binary systems. We have undertaken the design of such an experiment, aimed at the Omega-60 laser facility. The design elements include the production of postshock flows within a dense material layer or ejecta flows by release of material from a shocked layer. Obtaining a radiative reverse shock in the laboratory requires producing a sufficiently fast flow (> 100 km/s) within a material whose opacity is large enough to produce energetically significant emission from experimentally achievable layers. In this poster we will discuss the astrophysical context, the experimental design work we have done, and the challenges of implementing and diagnosing an actual experiment.

Background on Cataclysmic Binary systems

Cataclysmic Binaries (CBs) generally comprise of a white dwarf (WD) and a companion low mass main-sequence star. The nature of CBs depends primarily on the gas flow from the cool secondary star to the white dwarf.

• Gas streams towards WD but is diverted around it with excess angular momentum
• The stream produces a ring in lowest energy state
• Viscous processes and continued conservation of momentum cause ring to spread
• The accretion disc becomes fully formed

The supersonic gas stream that continues to flow, now impacts the outer edge of the accretion disc, forming a hot spot or bright spot, evidenced in spectral data

The nature of CBs is evidenced in the collision of stream and disc; two shocks become established, W1 and W2. The reverse shock in the stream, W1, can be quite radiative, contributing to the hot spot optical depth of shocked regions can be linked to the mass accretion rate such that

- Low accretion rate systems: optically thin to intermediate
- High accretion rate systems: optically thick

Simulations using different EOS’s to distinguish these systems, show very different structure in the hot spot region

Optical depth vs. structure and emission

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Isothermal EOS (optically thin)
- Shock waves over disc
- Larger overshoot of collision possesses significant inward velocity
- Adiabatic EOS (optically thick)
- Hot large expanding bright spot of the disc
- Some overmixing but not coherent stream
- Even in the absence of radiative cooling, the temperature declines rapidly downstream of impact

Target in OMEGA-60 chamber

Laser conditions:
- 10 beams
- ~450 Jbeam
- 1 ns square pulse
- 1011 Wcm2

Dante Diagnostic View

Basic DESIGN – Laser produced Sn plasma streamed into vacuum incident on thick quartz or Al wall

Simulations suggest design produces a radiative reverse shock that persists for ~10 ms, averages ~50-100 um thick by the end of its radiative phase

Diagnostic Design Geometry

SOP Diagnostic View

Orthogonal to tube SOP for propagation of stream and shock

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Future Work

These experiments will be carried out in August 2010 on Omega

Provided we can produce and diagnose a reverse radiative shock, later experiments for this platform include:
- colliding plasma stream with another denser stream
- changing scale heights of colliding streams to diagnose difference in interaction
- changing materials for different optical depths

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