Relativistic Shocks: Progress Report, August 1-September 1, 2016: A.Achterberg & C. Norman 29/09/ 2016.

During August we worked together intensively on the general theory of relativistic shocks. In this manifestly covariant approach the shocks carry significant currents and charges with consequent potential drops and magnetic field amplification.

Achterberg, in a tour de force, used the natural tetrad formalism to write out the general transport coefficients assuming isotropy in the shock frame and found explicit agreement with the previous opaque result of Gleeson. We thus have a general formalism for relativistic shocks that is a goldmine for future studies.

To study a mainstream problem with astrophysical applications in many areas of astrophysics including jets and Gamma-Ray Bursts, we have investigated the dissipative soliton-shock transition where the dominant dissipation mechanism is due to radiation drag. In, again, this manifestly invariant theory we reduced the system to an effective Sagdeev potential for the relativistic case. Here, though, there are three turning points and the potential is fourth order. The soliton solution is the analog of the classic Φ^4 potential.

The solution can be approximated to a two-timescale problem with the fast-timescale solution being a damped harmonic oscillator with a conserved classical action in the region where the oscillations are bounded between the potential walls. The long-timescale description describes how the magnetic field dissipates towards the shock solution on the slow timescale associated with the dissipative radiative drag. The second stable solution is the expected soliton.

The turning points associated with the extrema of the potential are the roots of a reduced cubic and that simplifies the problem. The subtle and difficult point, that we have now turned our focus on, is the way in which the dissipation changes the effective Sagdeev potential. That such an alteration of the potential occurs was well known to Biskamp, Sagdeev, Kennel and other early workers investigating non-relativistic solitons and shocks but most often the effect was felt to be ignorable. In the relativistic case, with its strong radiation drag, great care must be taken to carefully study the path to the shock solution including how the path depends on the dissipation. This is the next step in our strategy.

Notes on all the calculations described above are available on request. We hope to complete our first paper in a series by the end of May.

On a general note, C. Norman enjoyed many stimulating discussions with the faculty, fellows and graduate students in the vey lively Astronomy Institute at Radboud University. He thanks the Director, Paul de Groot and the Professors for their fine hospitality.