Vesa Ruuskaenen: The Beginning of a Hydrodynamic Description of Ultrarelativistic Heavy Ion Collisions

Larry McLerran

Physics Department and Riken Brookhaven Center

PO Box 5000 Brookhaven National Laboratory, Upton, NY 11973 USA

November 7, 2006

Abstract

Vesa Ruukanen's pioneering work on the hydrodynamical description of heavy ion collisions is recounted, along with a few personal anecdotes.

1 Keijo,Vesa and Me

The first time I met Vesa was was so long ago I do not remember the date. I was visiting Finland at that time for a couple of months, at we were both at a meeting of the Finnish Physical Society. The meeting was in the spring, and in spring it is still very cold in Finland. That winter had been so cold that all the polar bears ran off to Svalberg and all the penguins swam away to Antarctica, whenever that was. People walked on the ice all the way to Hamburg. A long time ago.

Keijo was the one introduced me to Vesa, who was playing billiards and drinking a beer in the lobby of the hotel. We played a few rounds of pool, drank a few beers, and have been good friends ever since.

I had been trying to understand Bjorken's work on hydrodynamics.[1] This paper was where he proposed the $1 + 1$ dimensional perfect fluid hydrodynamics equations for the evolution of matter produced in the central region of ultra-relativistic heavy ion collisions. Keijo and I were discussing how to modify these equations to include the effects of the fragmentation region of the nuclei. This is absolutely necessary for SPS energy collisions, and for the more forward regions of RHIC energy collisions. We had worked out hydrodynamic equations with sources.

Risto Raitio, Keijo and Vesa solved these equations numerically.[2] I studied this paper carefully. It introduced techniques for solving the hydrodynamic equations – and even more importantly, ways of visualizing the collisions and the flow of the matter after the collision. It was the first computation which treated the full longitudinal structure of the matter produced in heavy ion collisions.

Around the time of this work, I bought my first personal computer. I was connected by a 300 baud modem from my home, and could talk with colleagues by e-mail. This all seems trivial now, but it opened up a whole new world of collaboration – in particular, with my Finnish friends. I would receive a message in the morning which was the result of a day's work in Jyvaskyla or Helsinki. I would then work in the day, and send a message off which would reach their computers before they awoke, and the process would continue. I worked this way with both Vesa and Keijo,

I remember once early in the evening I got a message from Vesa saying, "Send me a joke." It must have been very late at night in Helsinki. I sent him one, probably about fishing or something. Next day I asked him why he had asked. He said he was having a party at his house with a couple of business men, and they wanted to see how e-mail worked. They were apparently very impressed.

I also learned in Helsinki that the US government was reading e-mail. I suspected it, as all foreign e-mail at that time went out through one portal in the US, at Georgetown University in Washington D. C. I had returned from Russia to Helsinki, and had some messages from Russian colleagues concerning how to invite some people to a scientific meeting, and other issues. About 6 months later at a physics meeting in Aspen Colorado, a very senior physicist who was associated with the secret Jason project, which was also meeting in Aspen at the time, made a point of telling me the contents of my e-mail.

Finland has always been in the leader in Europe in internet technology. I remember years ago when I would visit Germany my message would go off at the rate of one letter per minute, yet when I would be using e-mail in Helsinki it was like working in my home. The guest house of the University of Helsinki was one of the first University guest houses in Europe wired for internet.

2 3D Solutions

In 1983, while Vesa was doing the hydrodynamic computations described above, Baym and collaborators developed an elegant way to solve for the evolution of matter produced in the central region of ultra-relativistic nuclear collisions, which built in the transverse structure of the equations.[3] I had moved to Fermilab by then, and there was serious discussion in the US about building RHIC, so I thought numerically solving these problems would be a fun thing to do.

Well I put it on the computer and began solving and after a few iterations, the code always crashed. It took me months to figure out that I was seeing the formation of a shock front. I was grateful I was able to be talking with Vesa electonically, for I desperately needed his help. He kept telling me about characteristics and other stuff I have never understood. We somehow figured out that we should be using a hydrodynamic code developed by the people at Frankfurt for handling shock front formation, the flux conserving transport algorithm. Our collaboration had also expanded to include two excellent young people, Henrique von Gersdorff and Markku Kataja.

One of the difficulties of our collaboration was that I was running all my computations on a PC, and of course it was very slow and had very little memory by today's standards. I also had to use turbo Pascal as this was the only efficient compiler available at that time. It was clear we had to shift to a bigger machine, and this involved translating everything into Fortran. Henrique made the heroic effort to translate my poorly written code, and Markku turned the code into an efficient algorithm. Vesa for many years afterward would complain bitterly about the sloppy manner in which I wrote code, but, it worked for me.

In spite of Vesa's unhappiness with my skills in numerical computation, we managed to publish three papers on this subject.[4] These papers were important since they were the first to give some understanding of the time scales of transverse expansion. An interestinging feature was that the system did not grow very large in the transverse direction, and a rarefaction shock wave formed near the density of the transition between a quark gluon plasma and a hadronic gas.

Later, Vesa, George Bertsch and I teamed up together with two young people, M. Gong and E. Sarkkinen, to understand what would happen if the nuclei in a heavy ion collisions fragmented into globs of quark gluons plasma, as might happen at a first order phase transition. These globs radiate pions at their surface, and the pions scatter by cascade computation. This was a project with which we had a lot of fun. We especially enjoyed getting to know George, and his deep and clever insights into nuclear physics. I still think there is some truth in the picture we developed together, but it is long since lost in the sands of time.

I think it is fair to say that Vesa was the one who started the serious hydrodynamic computations for ultrarelativistic nuclear collisions. This area has grown into a very successful enterprise. The evidence for thermalization in RHIC collisions comes primarily from comparing computations with data on radial and elliptic flow. The agreement is very impressive. Vesa has produced a number of excellent PhD's working in these areas, most recently Pasi Huovinen and Kimmo Tuominen.

The Finnish work on these problems is always reliably and carefully done. It is work marked by a physical insight, done to test a theoretical hypothesis. It is not mindless computation, and it has had a major impact on high energy nuclear physics – both as seminal work and as lasting work of substance.

From the time Vesa and I first worked together, we have remained very good friends. I have visited him in Jyvaskyla, and had him rescue me once when I locked myself and Alice out of our room as we were leaving the guest house to catch a train. Unfortunately, our suitcases were still inside. We seemed destined to miss our train, Vesa pulled some sort of rabbit out of his hat, and got the door opened. I no longer remember how he did it, only that at the time it seemed an impossible feat of magic.

We skied together at many meetings. In Hirschegg I went out with Vesa and Helmut Satz on cross country skis, and we went up in hilly terrain. If you have skied with Vesa and Helmut, you know their skill at that sport. If you have skied with me, you can understand how challenged I was. There was no way any thing human, animal or from some other planet could keep up with Vesa on skinny skis, but Helmut was in his league. One would look for the steepest hill, sail on down it, and the other would follow close behind. Much later, by whatever means I could manage, I would join them at the bottom of the hill.

The last time we were skiing together was about ten years ago, I was an organizer of a meeting in Seattle and I invited Vesa and Kris Redlich to my house in Oregon for a few days of skiing. We spent many hours skiing. Mainly I went on the downhill slopes and Vesa went cross country. When I did ski with him on skinny skis once, I found he would go twice around the course while I was going around once. In any case, we would return happily worn out, no longer feeling any need to be thinking before speaking. That relaxed freedom is one of the luxuries of a good friendship.

Vesa is always an optimistic person with an idealistic view of the world. At the last scientific meeting which we both attended, he spoke to me with great heat about US policy in Iraq, which he assumed I supported. As a matter of fact, I share those misgivings. I wish I could match his optimism. But identical opinions are not a requirement for friendship. Friends, like partners in marriage, can with luck have very different views and many heated discussions and still stay close.

Vesa is now retiring from the physics department. Knowing Vesa, I trust the main change in his life is going to be that now he can have more time to do physics.

3 Acknowledgements

I gratefully acknowledge Kari Eskola and Kimmo Kainulainen who have put together the collection of anecdotes about Vesa, organized and who asked me to contribute.

This manuscript has been authorized under Contract No. DE-AC02-98H10886 with the U. S. Department of Energy.

References

[1] J. D. Bjorken, *Phys. Rev.* **D27** 140 (1983).

[2] K. Kajantie, R. Raitio and P. V. Ruuskanen, *Nucl. Phys.* **B222** 152 (1983).

[3] G. Baym, J. P. Blaizot, W. Czyz, B. Friman and M. Soyeur, *Nucl. Phys.* **A407** 541 (1983).

[4] H. von Gersdorff, M. Kataja, L. McLerran and P. V. Ruuskanen, *Phys. Rev.* **D34** 811 (1986); 2755 (1986); K. Kajantie, M. Kataja, L. McLerran and P. V. Ruuskanen, *Phys. Rev.* **D34** 2755 (1986).

[5] G. Berstch, M. Gong, L. McLerran, P. V. Ruuskanen and E. Sarkinen, *Phys. Rev.* **D37** 1202 (1988).