

EPJA-103864

Challenges in QCD matter physics - The scientific program of the Compressed Baryonic Matter experiment at FAIR

by Friese Volker et al.

The aim of this review is to describe the CBM detector at FAIR and how this detector should unveil the details of the QCD phase diagram as a function of net baryon density and temperature beyond what we know today. This review is appropriate, timely and useful and deserves publication in EPJA.

Sections 2, 3, 4 and 5 are well written and complete, though at times very technical and difficult to follow for a non-expert; this statement includes theoreticians working in the field. In section 1, the authors go in some detail to describe our present theoretical description of the phase transition, namely the existence of a crossover region, a critical point, the expected type of phase transition beyond the critical point, the possible presence of exotic matter, the phenomenon of chiral symmetry restoration,...and they formulate important and motivating questions, but how these are related to the observables is not discussed.

For example, after the nice theoretical description of the phase diagram in section 1, section 2, begins right away and I quote,

"Most of the experimental observables which are sensitive to the properties of dense matter like the flow...., are extremely statistics demanding."

and this is all there is to the relation between the physical scenarios and the observables.

The theoretical framework and expectations should be connected to observables in the first section. This is a review for physicists and therefore the connection between theory and experiment should be done before going into the details of the various experiments and the CBM. In my opinion, a paragraph at the end of section 1 describing the wished observables and how they unveil the physical scenarios in the phase diagram, would be very illuminating and would make more appealing the forthcoming sections which tend to be rather technical.

In section 4, "Probes of high density matter", there is discussion of the implications of each observable and their relation with the phase diagram separately: directed flow is connected with EOS, event-by-event fluctuations with the determination of the critical point, lepton pairs with chiral symmetry restoration etc... However, in this way one loses a global perspective of the research project and moreover, one is not aware of these relations in sections 2 and 3.

Again in the conclusions I would summarize by elaborating more on how the experiments will determine the phase diagram.

Having said this I turn to some particular comments:

The authors should make an effort to complete the bibliography. This is supposed to be a review and reviews are characterized for having a complete bibliography.

For example, in section 1 while describing the phase diagram the authors discuss quarkyonic matter, but there have been other extremely interesting scenarios: i) crystalline skyrmionic matter, e.g. Hee-Jung Lee et al., Nucl.Phys. A723 (2003) 427,.....; ii) color flavor locking phases, e.g. M. G. Alford et al., Nucl.Phys. B537 (1999) 443.....; and Ref[15], Nambu-Iona-Lasino models, e.g. M. Orsaria et al. PRC89(2014) 015806,..... By the way the last reference appears in page 5 first column, in the sentence, I quote, "The development...". It should go at the beginning with the other scenarios. If this suggestion is accepted then one of the questions should change to: Do exotic phases exist?

Another example is related to EOS, only one reference [32] a field to which many people have contributed, Lattimer, EPJ Web Conf. 109 (2016) 07001, Blaschke, J. Phys.Conf.Serv. 668(2016) 012042, Russotto et al Phys.Rev. C94 (2016) 034608,.....

No citation of fluctuations arising from criticality, I recall, NA49 Phys.Rev. C92 (2015) 044905, Eur.Phys.J. C75 (2015) 587, PHENIX, PoS CPOD2014 (2015) 075,...

The same happens with strangeness and charm, few citations.

Thus in conclusion in my opinion the referencing should be updated and extended.

Despite the fact that it is questioned in the introduction: to what extent are the properties of hadrons modified in dense baryonic matter? There is discussion about strange production and charm production in the medium but nothing is said about conventional mesons, like how the properties of rho, omega meson,.. change in the medium A. Ramos et al. Eur.Phys.J. A49 (2013) 148, HADES PoS QNP2012 (2012) 005,..... Also glueballs are not mentioned at all Parganlija Eur.Phys.J. A52 (2016) 229, Kochelev Eur.Phys.J. A52 (2016) 186, Stoecker et al, J.Phys. G43 (2016) 015105,...

Finally I have seen some minor latex problems: going over the margins and invisible colors (yellow for examples). There is also a little problem between English and American spellings color, colour and behavior, behaviour.

Summarizing, this is a good review paper, which should be published. However, since it is a review and not a technical internal communication, it should be made available to a wider audience and therefore physics should be the leitmotiv. Thus, I would urge the authors to establish a more transparent and global connection between theoretical ideas and experimental observables, to relate these discussions to the design and research project of CBM and to increase and update their bibliography.