Correcting a prejudice regarding high-energy nuclear collisions

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At the end of next year, CERN's Large Hadron Collider (LHC) is scheduled to go online. Already, there are four major experiments planned and one of them, ALICE, is dedicated to the study of heavy-ion collisions. Rudolph Hwa, a professor at the University of Oregon, says that the objective of a heavy-ion collider is to produce quark-gluon plasma (QGP), which is thought to be the matter existent at the beginning of the universe, just after the Big Bang.

Hwa's interest in the scheduled experiments at LHC is related to a Letter published July 26 in *Physical Review Letters*. Together with his collaborator, Chunbin Yang at Hua-Zhong Normal University in the People's Republic of China, Hwa has written a paper, titled "Proton Enhancement at Large pT at the CERN Large Hadron Collider without Structure in Associated-Particle Distribution," describing a way to determine how quarks and gluons turn into hadrons.

"There is no way to detect the quarks or gluons directly," Hwa explains to *PhysOrg.com*. "But they turn into hadrons — protons and pions — and these we can detect. That step in between is called hadronization."

Hwa says that "there are two possible ways that hadronization can occur: fragmentation and recombination."

Hwa explains that fragmentation is the conventional wisdom. "It's been tested in other experiments where the colliding particles are electrons or protons and where no QGP has been produced. It's been applied to heavy-ion collisions at LHC." He pauses. "But if a super-dense medium like a QGP can be created at LHC, fragmentation may not be the most important process in certain regions."

Hwa and Yang see a different possibility. "We question whether another mechanism is more relevant — recombination." Explains Hwa: "The paper attempts to correct a prejudice in the conventional thinking about multiparticle production in high-energy nuclear collisions. When the density of jets produced is high, the recombination of shower quarks in adjacent jets can be the dominant process in hadronization."

The Letter also explains how ALICE experimenters could possibly determine which mechanism is the correct explanation for hadronization. By analyzing the results of the experiment, it should be possible to determine the correct scenario by the ratio of pions to protons produced. "In the case of fragmentation," says Hwa, "you would see more pions than protons. In the case of recombination, the opposite is true. You would detect more protons than pions."

Hwa and Yang's Letter also points out a notable lack of associated particles distinguished from the background in the recombination scenario: "With fragmentation, you see a particle coming out identified as a trigger and find that there are other particles associated with it. With recombination, we predict that the associated particles will be indistinguishable from the background."

"Our paper is mostly academic," explains Hwa, "with little significant societal impact. Hadronization is only the final part of the overall process in a heavy-ion collision. But it is necessary to understand it properly in order to determine what is going on in the middle of this small but very dense medium. We are trying to say that it is possible that something different may be happening in the last step. Something different from the conventional wisdom."

Hwa hopes that the ideas in his and Yang's Letter will be considered when the data from the experiments at LHC are analyzed two or three years down the road. "This is a technical point," explains Hwa, "but if you don't know the process, how will you be able to know reliably what goes on inside the quark-gluon plasma?"

And, after all, learning about quark-gluon plasma is the point of the experiments on heavy-ion collisions at the CERN LHC.

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