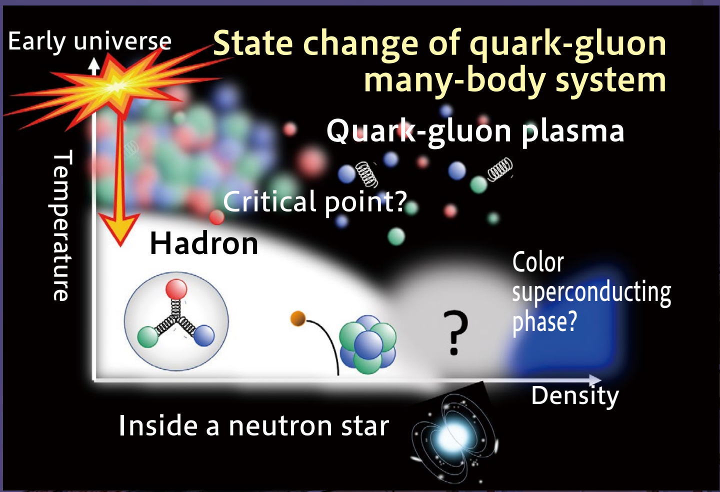

State change of quark-gluon many-body system, related to the early universe and neutron stars

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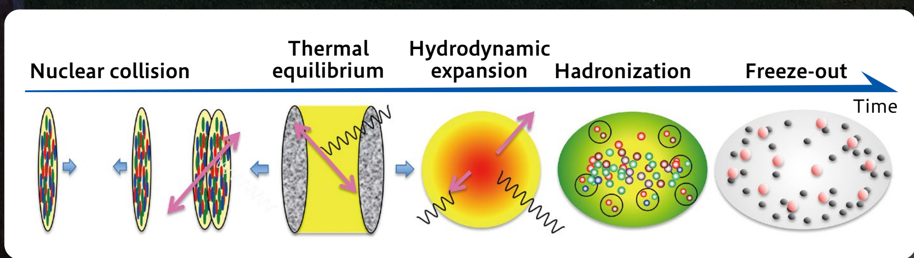
Research interests
Nuclear physics, hadron physics

Exploring the beginning of the universe through quarks

Have you ever heard of the term "quarks"? At present, quarks are believed to be the smallest fundamental building blocks of matter. The particles responsible for the interaction between quarks, called "gluons," are normally confined within protons and neutrons in our everyday world. However, under extreme conditions, such as incredibly high temperatures and densities, this confinement can break down, allowing quarks and gluons to move freely, changing into a new state. This state is referred to as "quark-gluon plasma" (QGP). QGP is not a theoretical concept, but it is in fact thought to have existed in reality, just one-hundred thousandth seconds after the Big Bang. More surprisingly, scientists have succeeded in artificially creating QGP on Earth!

How have they succeeded? It was through high-energy heavy-ion collision experiments. Since the 1970s, a series of such experiments has been conducted, and in 2000, the Relativistic Heavy Ion Collider (RHIC) began operating at Brookhaven National Laboratory in the United Sates. In 2005, it achieved the breakthrough of successfully producing QGP. You might find it strange that I say "successfully producing QGP" rather than "discovering" it. This is because QGP cannot be observed directly. As mentioned above, quarks and gluons are typically confined within protons and neutrons. This means that all we can observe in experiments are photons and hadrons such as protons. This is where theoretical interpretation becomes critical. That is to say, scientists must develop theories that incorporate the production of QGP and test whether these theories can explain the experimental results. At the time, many theories were proposed, and the one that appeared particularly promising was what is known as the "relativistic hydrodynamic model." This model has been particularly effective in interpreting a wide range of experimental data and has now become the standard model for describing the dynamics of high-energy heavy-ion collisions.

My research team had already been analyzing data using the relativistic hydrodynamic model before RHIC began operations. At that time, only a small number of research groups worldwide were seriously applying such a bold model, which describes the particles produced in a collision as a fluid. However, after RHIC's success in creating QGP, this approach quickly gained attention and recognition. In scientific research, you don't know what turns out to be successful or what attracts attention until the very moment it happens, and this is what is really challenging and fun at the same time for researchers. I hope to continue doing my best in my research, keeping in mind that all types of knowledge must be subjected to experiments.



Space-time evolution after a high-energy heavy-ion collision

〈Background photo〉
Niels Bohr Institute, where Prof. Nonaka stayed in November 2023. The institute is named after Niels Bohr, the "father" of modern physics.