

First observations of tongue deformation of plasma based upon the Artsimovich Prediction

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At the National Institutes of Natural Sciences National Institute for Fusion Science researchers, in collaboration with Kyushu University, observed for the first time in the world a deformation called the 'tongue deformation' occurring locally in a Large Helical Device (LHD) plasma. This deformation was predicted by Lev Artsimovich in the late 1960s. Since then it has not been observed experimentally, becoming a riddle in plasma physics not solved for 50 years.

Aiming for the achievement of fusion energy, research on confining a high temperature, high density [plasma](#) in a magnetic field is being conducted around the world. In a plasma confined by the toroidal magnetic field, as the pressure rises (higher temperature and higher density) there is a tendency for the plasma to become unstable. Depending upon the condition, the plasma changes its shape, and then its temperature and density fall (this behavior is called "instability"). There are two kinds of instability which appear from rising pressure. The first kind causes the localized tongue deformation which appears only in weak regions of the [magnetic field](#). The second kind of instability (called the mode) causes changes in the entire plasma. These two instabilities were proposed in 1968 by Artsimovich. The change called "mode" is generated throughout the plasma and modes continue for a long period of time. And because they are comparatively easy to observe, numerous modes have been verified experimentally. On the other hand, because the tongue deformation is localized, it appears in only one region inside

the plasma. Moreover, because it continues for only 1/10,000th of one second, observation is difficult, and the deformation had not been verified experimentally. The temporal length of this deformation is short. However, due to this instability, because the abrupt collapse phenomenon occurs, it has been indicated theoretically that the plasma's good confinement becomes deteriorated.

The research groups of Professor Katsumi Ida and Assistant Professor Tatsuya Kobayashi, both of NIFS, in collaborative research with Professor Shigeru Inagaki, of the Kyushu University Research Institute for Applied Mechanics, observed for the first time in the world the deformation of a localized plasma called a tongue in the LHD. Here, rather than observing the abrupt collapse phenomenon, by focusing upon small changes just prior to the abrupt phenomenon they found the tongue deformation. Moreover, in the plasma's abrupt collapse phenomenon caused by the tongue, as a result of a detailed investigation of the velocity distribution of protons they observed for the first time the distorted velocity distribution. That the distortion of real space causes the distortion of phase space is linked to the discovery of this phenomenon.

This discovery of the tongue deformation in the LHD has confirmed experimentally Artsimovich's prediction. And at the same time as being a result that solves a fifty-year old riddle in the plasma, it also offers a guideline for maintaining high temperature and high density plasma. And its contributions are greatly anticipated for achieving new developments in fusion research around the world. This tongue deformation may also be called a portent of unexpected phenomena, and of the many sudden phenomena which occur in nature (for example, solar flares, etc.). This means that the importance of "localized change" as a portent was indicated. In the future, still further scholarly ripple effects are anticipated.

This result was published in the English-language academic journal *Scientific Reports*, published by *Nature*, on October 31, 2016, and is widely available.

More information: K. Ida et al, Abrupt onset of tongue deformation and phase space response of ions in magnetically-confined plasmas, *Scientific Reports* (2016). [DOI: 10.1038/srep36217](https://doi.org/10.1038/srep36217)

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