Surfatron acceleration and high energy particle in plasmas

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After an innovative idea of the surfatron (surfing) acceleration proposed by Sagdeev and Shapiro in 1973, there has been a great deal of interest of high energy particle acceleration in shock acceleration in space and astroplasmas and beat-waves in laser plasmas. The conventional surfatron acceleration utilizes an external magnetic field and an electrostatic field perpendicular to the magnetic field, and non-adiabatic acceleration occurs for the case of a large-amplitude and localized electric field, which scale is shorter than the gyro-radius. The energy gain is provided by the motional electric field perpendicular to both the magnetic field and the electrostatic field. Recently, in addition to the conventional electrostatic trapping process, it has been discussed that an anti-parallel magnetic field structure induced by a large-amplitude magnetosonic wave can play the similar role on the particle trapping as well, and it has been shown that the surfatron acceleration occurs even in electron-positron plasmas, where no strong electrostatic field is excited. It is believed that the surfatron acceleration can be applied in many plasma settings than before. Another recent progress is the unlimited acceleration in relativistic regime. Once the particle is accelerated into a relativistic speed, it is completely trapped inside the acceleration channel, and the final acceleration energy can quickly reach to the available potential energy of the system. In this way, this mechanism has received much attention as a new modeling of high energy phenomena in plasma universe.