Electron shock surfing acceleration and electron escape into upstream region in oblique shocks

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Electron shock surfing acceleration in an oblique shock is studied by using a particle-in-cell simulation. We find that the efficiency of nonthermal electron acceleration increases with decreasing the shock angle from perpendicular to oblique shock, and that the maximum acceleration efficiency is observed around 70 degree of the shock angle. In further oblique case, the production of the nonthermal electrons is gradually reduced. In this regime, a part of the accelerated electrons in downstream can escape along the magnetic field into the shock upstream, which in turn thermalize the upstream incoming cold electron through two-stream instability. We discuss that the increase of the nonthermal electron acceleration around 70 degree is provided by the shock surfing acceleration under the action of the weaker magnetic field in the oblique shock, while the reduction of the nonthermal electron for quasi-parallel shocks is affected by the reduced emission of electric field controlled by the upstream pre-heated electron.