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Electric field by pick-up ions and electrons

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Observations by the Rosetta Plasma Consortium (RPC) showed increasing distortion of the solar wind flow as Rosetta approached the Sun, i.e., as the density of the newly born ions increased. This indicates azimuthal momentum transfer from the solar wind to the newly born ions because they are displaced by the solar wind electric field up to the ion gyroradius this the solar wind velocity, and conservation of the momentum (center of the mass) makes the solar wind to azimuthally shift by "counter action" of these pick-up ion motions.

To understand this azimuthal momentum transfer, it is inevitable to model the electric field by the displacement of these pick-up ions and electrons. Although the E×B drift does not make charge separation when the scale size is larger than the ion gyroradius, ions and electrons move in the opposite direction to each other within the short distance up to a gyroradius, and therefore, the charge separation occurs. Thus, the newly-ionized neutrals (ion-electron pairs) create the electric field in the opposite (shielding) direction to the solar wind electric field (like the ionopause of Venus and Mars).

However, such a newly induced "shielding" electric field will simultaneously be weakened by the solar wind electrons because the solar wind is also moved by this shielding electric field to reduce it, in the same way as the plasma oscillation (time scale of about 10^{-4} s). In other words, the solar wind tries to maintain the solar wind electric field as far as the momentum allows.

These two opposite effects must be combined when modelling the azimuthal electric field, and resultant ion/electron motions within a gyroradius, like the case for ROSETTA. Furthermore, the effect of the induced electric field by the pick-up ions and electrons will be different when the newly born ions are created as the result of photo-ionization and of the charge exchange because the electron effect is different between them.

In the presentation, we model the combined electric field assuming quasi-2D assumption by ignoring the X component ($-X$ is along the solar wind direction).