On the bi-polar magnetic structure at the leading-edge of reconnection jets

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A recent paper by Slavin et al. [2003] shows that
some of the jets in the magnetotail
have a bi-polar magnetic structure at their leading edges.
It is characterized by southward-then-northward variation
for earthward jets, and vice versa.
In this paper, we try to model this feature
in terms of three-dimensional reconnection with non-zero
guide field.
Here the coordinates system is the conventional one
used for magnetotail studies.
As the initial condition for the three-dimensional MHD simulations,
we set a Harris current sheet Bx=tanh(z) with uniform guide field
By=By0. Reconnection is initiated by putting an ad-hoc
anomalous resistivity in a localized region that has a finite extent
in the y (dawn-dusk) direction as well, whose half-width is denoted by Ry.
Such a three-dimensional reconnection in the presence of the guide field
results in the leading-edge structure as follows:
(1) The jet is bifurcated to higher-latitudes at the leading edge.
(2) When By is non-zero, unlike the By=0 cases,
the bifurcated jet is rotated in the yz plane. When By is positive and
for the earthward propagating part, hot and fast flowing plasma is
located at north-dusk and south-dawn quadrants.
(3) Upon arrival of the bifurcated jet leading part,
plasma flow in the yz plane is generated as the
two spots of hot plasma try to expand.
(4) The flow in the yz plane bends the magnetic field line at the equator
such that the Bz component is negative at the midnight meridian.
(5) In the earthward jet itself, the Bz component is positive.
Data from a spacecraft situated at the equator over which
this earthward jet passes would
record southward-then-northward variation in the magnetic field,
which is indeed reported by Slavin et al.
The behavior of the By component,
the Vx component, and the plasma density also show
good qualitative agreement with the data.
These hold the same when By is negative.
To make an quantitative assessment, we have focused on
the minimum Bz during the events, which is reported to be -3 nT on average,
and explored in what (By0, Ry)-space the initial condition has to be
to have the minimum Bz to be equal to this value.
For By0=4 nT, which is the reported typical guide field strength,
we find that Ry must be 4 times the half current sheet thickness.
Taking the half-thickness to be 1,000-3,000 km, the dawn-dusk width
of the reconnection jet (2Ry) is determined to be 1-4 Re.