1. Classification *INPE-COM.10/PE* *CDU: 537.531:525.24*	2. Period *August 1976*	4. Distribution Criterion internal [ ] external [X]
3. Key Words (selected by the author) *X RAY SOURCES, MAGNETIC FIELD MERGING, ASTROPHYSICAL BINARIES.*		
5. Report Nº *INPE-933-PE/036*	6. Date *August 1976*	7. Revised by Ricardo A. R. Palmeira *R.A.R. Palmeira*
8. Title and Sub-title *X RAY SOURCES AND MAGNETIC FIELD MERGING*		9. Authorized by Parada *Nelson de Jesus Parada* *Director*
10. Sector *CEA/AST*	Code *411*	11. Nº of Copies - *04*
12. Authorship *W.D. Gonzalez-Alarcón* *A.L.C. de Gonzalez*		14. Nº of Pages - *10*
13. Signature of the responsible W. Gonzalez		15. Price 8,00

16. Summary/Notes

17. Remarks *This work is to be submitted as a Letter to Nature Physical Science.*

X-RAY SOURCES AND MAGNETIC FIELD MERGING

by

W.D. Gonzalez and A.L.C. de Gonzalez
Instituto de Pesquisas Espaciais - INPE
C.P. 515 - 12200 São José dos Campos - SP - Brasil

Due to the accumulation of data and theoretical work during the last decade, it has become conclusive the importance that magnetic field merging (MFM) between the interplanetary and terrestrial magnetic fields plays for the earth's magnetosphere. What MFM does for the magnetosphere can be summarized as follows [1,2]. The topology of the closed geomagnetic field at the merging regions (dayside magnetopause and tail) changes to an OPEN configuration facilitating the entry of plasma and the establishing of convection in the magnetosphere. The plasma enters the magnetosphere at the dayside through the northern and southern clefts and at the nightside from the tail, populating the plasma sheet. The less energetic components of the plasma contribute to convection and the more energetic ones populate the ring current, precipitate into the auroral regions via the cusps and may even contribute to populate the Van Allen belts. The power gained by the plasma due to the merging process and the stretching of the open field lines by the solar wind is enough to energize the magnetosphere [3,4].

Considering that the open magnetosphere hypothesis is a working model for the sun-earth system, that explains observations, it seems reasonable to extrapolate the main features mentioned above to astrophysical stellar binary systems, in particular to those which are currently reported as X-ray sources.

The type of close binaries which are usually discussed as X-ray sources have secondary objects accreting mass from a primary star wich either fills the Roche lobe and transfer mass to the secondary through the inner Lagrangian point forming a disk, or transfer mass via a stellar wind with the accreting matter not necessarily forming a disk[5]. Since we are interested in developing an analogy between the sun-earth system and X-ray binaries, we choose, as a primary, a star with a magnetized stellar wind and, as a secondary, an object with a reasonably strong magnetic field which could be a "normal" star (e.g. in its main sequence stage), a white dwarf, or a "slow" rotating neutron star. A black hole does not seem to have a magnetic field[6]. The assumption of a "slow" rotating neutron star implies that, at the merging regions, convection dominates corotation. This requirement puts an upper limit to the rotational frequency of the secondary.

For the purpose of illustration we assume in Figure 1 a dipolar configuration for the magnetic fields of both objects, and antiparallel magnetizations since MFM seems to be more efficient for colliding antiparallel magnetic fields [7,8]. Figure 1 also shows the standing shock in front of the magnetopause and the magnetic topology of the system with the "dayside" and "nightside" merging (X) regions. The white arrows indicate the plasma flow (convection). We can think of a steady configuration of convection at the outher magnetosphere and accretion of mass to the secondary (through the clefts and cusps), whose rates are probably regulated by boundary conditions such as the mass to radius ratio of the secondary and the luminosity of the radiating regions (mainly bottoms of clefts and cusps).

The accretion models presented in the literature to explain observations from X-ray sources, usually assume a magnetic axis of the secondary almost perpendicular to its rotational axis, with a consequent "easy" accretion of mass along the polar field lines. The importance of MFM, especially for the cases that the magnetic and rotational axes are almost aligned, is that it facilitates accretion into the "auroral" regions of the secondary along the accesible open field lines (opened by the merging process). It MFM were not present for those cases, the magnetosphere would be a closed cavity and accretion inefficient.

Our discussion is restricted to the cases for which the primary provides mass to the secondary via a supersonic stellar wind and accretion follows without the formation of a disk (typical when the transfer of mass is through the inner Lagrangian point of the system).This restriction also eliminated secondaries which rotate "too fast", as mentioned above, and therefore force the wind to corotate before the wind reaches the magnetopause, forming also a disk. MFM at the inner boundary of a disk (Alfvēn surface) is innefficient mainly because the merging speed (normal to the surface) becomes negligible. However, our discussion could be extended to binaries which have rapidly rotating secondaries that have evolved to a slower rotation regime due to the loss of rotational energy through the disk.

The X-ray luminosity is produced by accretion mainly at the auroral regions of the secondary in a manner similar to that described in the literature [5]. However, for some "extreme" cases, namely, strong stellar wind, antiparallel magnetic fields at the magnetopause and strong magnetic field of the secondary, X-rays could also be produced at the merging regions due to a thermal emission from the plasma heated by the shock and the merging process and due to synchroton emission from electrons accelerated by the strong electric field at the merging regions. Therefore, several "hot regions" that emit X-rays may exist when MFM is present in a binary. The combination of several factors such as the inclinitation of the binary orbital plane with respect to the observer, the degree of alignment of the magnetic and rotational axes, the nature of the secondary and anisotropies in the radiation transfer may produce several interesting observational features related with periodicities, occultations, fluctuations and so on. The main source of fluctuations is probably related to the nature of the merging process itself.

Applications of the above discussion to X-ray sources give rise to interesting preliminary alternative models for some of the best known sources [9]. In particular, X-ray observations from Cyg X-1 which are usually explained by accretion onto a Black Hole (due to the large mass inferred for the secondary), may be explained by accretion onto the auroral regions of a magnetized main sequence star with MFM regulating accretion and therefore giving a natural explanation to the observed fluctuations. A similar conclusion has been reached by Bahcall et al., 1973 [10], with however a somewhat different assumption, namely, twisting between the magnetic fields of both stars that also lead to MFM. The main difference between the twisting-merging implications and our wind-merging ones is that the lifetime of the X-ray source related to twisting-merging is several orders of magnitude shorther than for wind-merging.

We would like to reinforce the idea that the above discussion is not restricted to close binaries with antiparallely magnetized objects (like in Figure 1). MFM occurs also for colliding magnetic fields with almost any angle between them [7,8,11]. The main result out of this is that the magnetic field of the secondary will be OPEN almost independent of the angle between the magnetization vectors of both objects, facilitating accretion and therefore the occurrence of X-ray sources when disks are not formed.

A further comment on the analogy between the earth's magnetosphere and some magnetospheres related to X-ray sources is addressed to a future speculative work about plasma sheets, ring currents, Van Allen belts and so on.

FIGURE CAPTION

Figure 1 - Magnetic topology of a close binary in a "noon-midnight" meridional plane with antiparallel magnetization vectors. The white arrows indicate convection. The dotted line shows a standing shock. The X marks indicate the merging regions which in three dimensions are lines on the "equator", along the "magnetopause" and across the "tail".

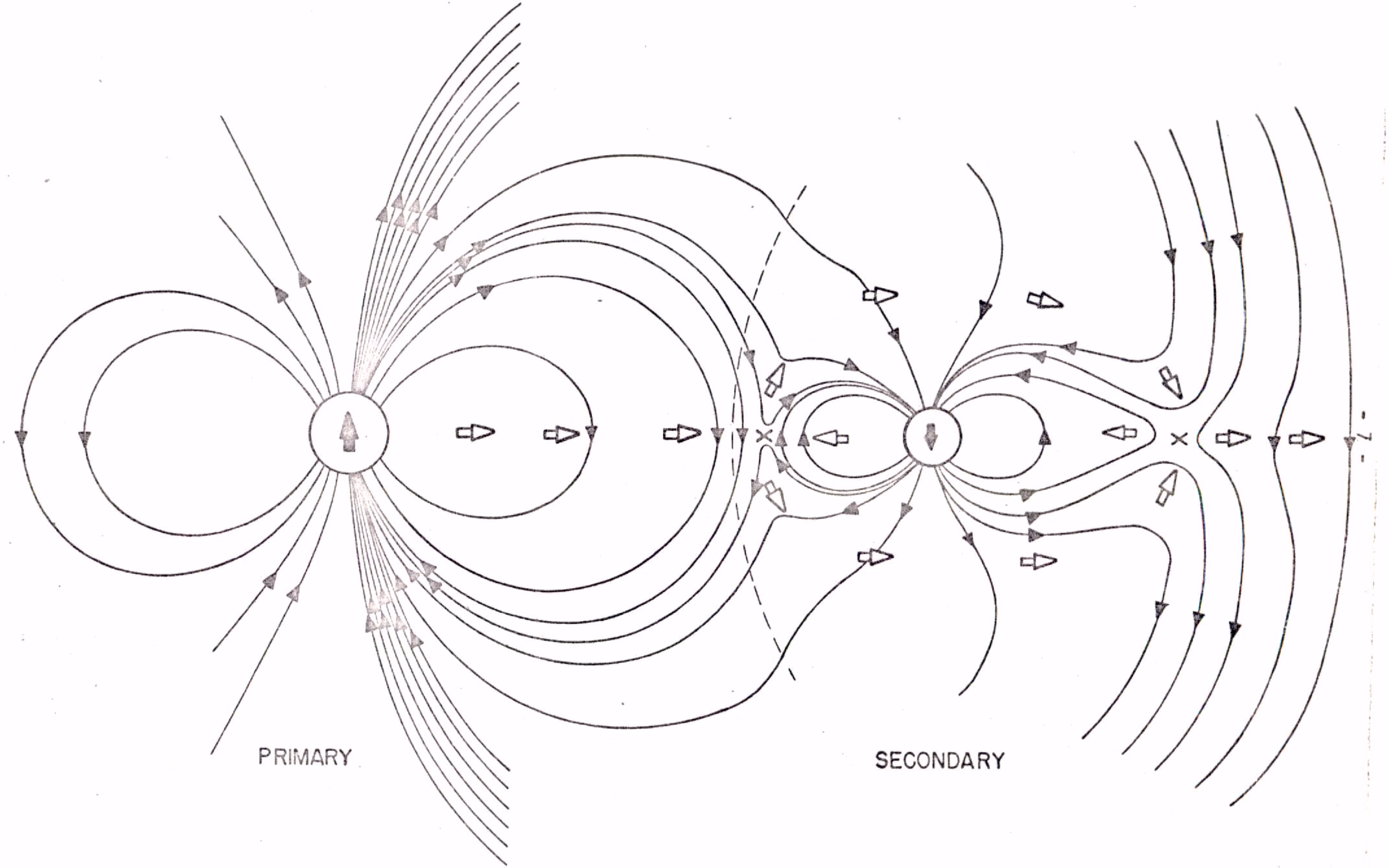

Figure 1

W.D. Gonzalez-Alarcōn and A.L.C. de Gonzalez

REFERENCES

1 - BURCH, J.L., Rev.Geophys. Space Phys., 12, 363, 1974.

2 - HILL, T.W.; WOLF, R.A., Solar Wind Interactions, Rice University, preprint 1976.

3 - PETSCHEK, H.E., AAS-NASA Simposium on Physics of Solar Flares, Ed. W.N. Hess, NASA SP-50, 1964.

4 - GONZALEZ, W.D., Ph.D. Thesis, University of California, Berkeley, 1973.

5 - BLUMENTHAL, G.R., TUCKER, W.H., Ann.Rev.Astron.Ap., 23, 1974.

6 - MISNER, C.W., THORNE, K.S., WHEELER, J.A., Gravitation, San Francisco, Freeman, 1973.

7 - GONZALEZ, W.D., MOZER, F.S., J.Geophys.Res., 79, 4186, 1974.

8 - SONNERUP, B.U.Ö., J.Geophys.Res., 79, 1546, 1974.

9 - GONZALEZ, W.D., GONZALEZ, A.L.C., Magnetic Field Merging and Astrophysical Binaries, in preparation.

10 - BAHCALL, J., KULSRUD, R., ROSENBLUTH, M., Nature Phys.Sci., 243, 27, 1973.

11 - YEH, T., J.Geophys.Res., 81, 2140, 1976.