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Author: Paulo R. Klaudat
Advisor: Raphael M. Brum

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Comparing Spice Model of STT based MTJ with Micromagnetic Simulations

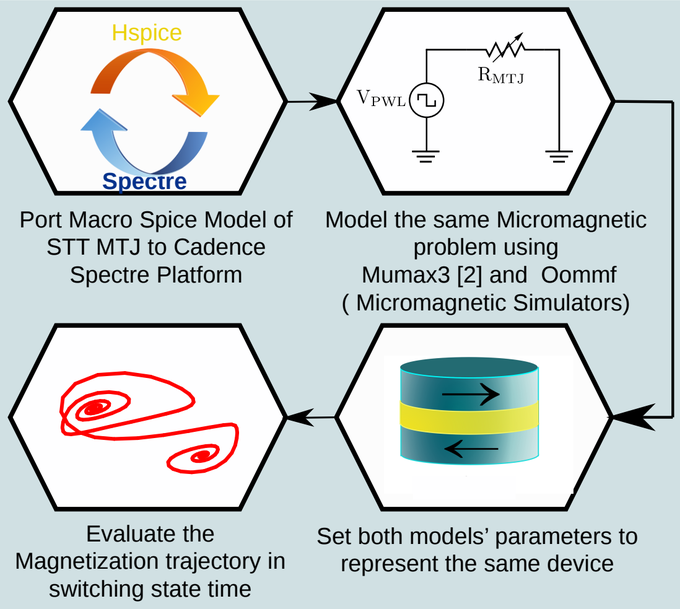
Introduction

In ferromagnetic layers the Magnetization can be described by the Landau Lifshitz Gilbert equation:

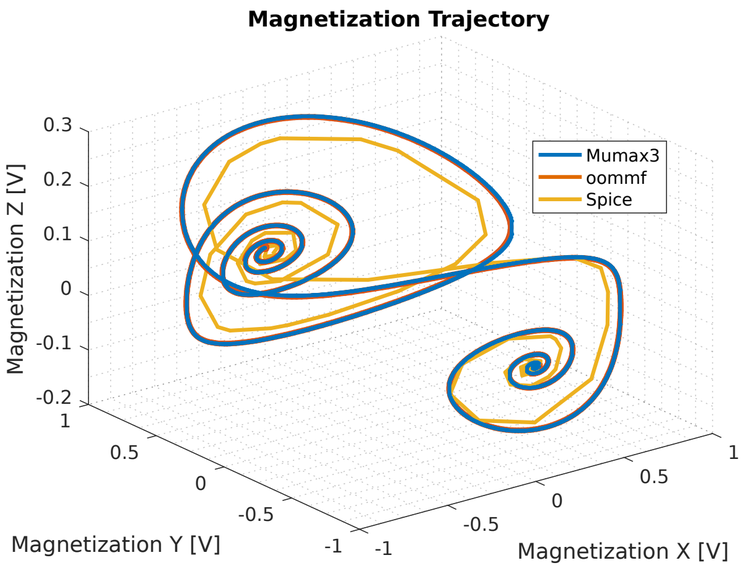
$$\frac{1+\alpha^2}{\gamma} \cdot \frac{d\vec{M}}{dt} = -(\vec{M} \times \vec{H_{\text{eff}}}) - \alpha(\vec{M} \times (\vec{M} \times \vec{H_{\text{eff}}})) - \frac{\hbar J}{eM_s d} G(\theta)(\vec{M} \times \vec{M} \times \vec{p})$$

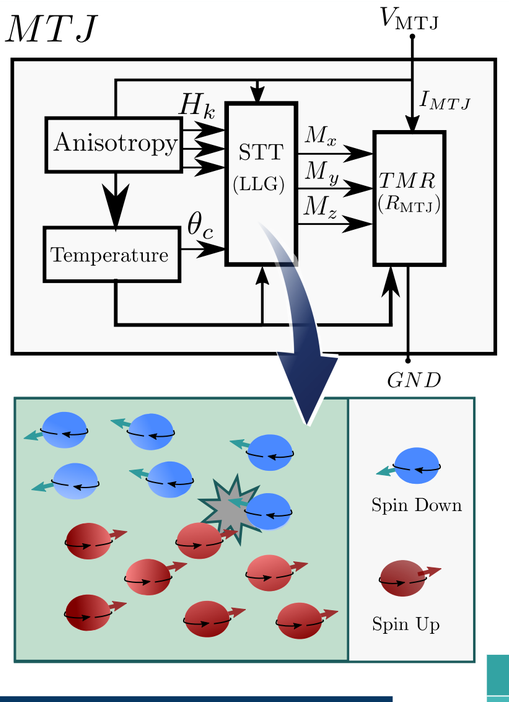
In this work we present a comparison with the Golden Standard to solve Micromagnetic problems and the Macro Spice model [1] of a device called Magnetic Tunnel Junction (MTJ), which is made by two stacks of ferromagnetic layers and an insulator [3]. Through the Spin Transfer Torque (STT) mechanism this device can change its self Magnetization orientation and promotes a change of resistance magnitude that portrays the great feature of MRAMs arrays.

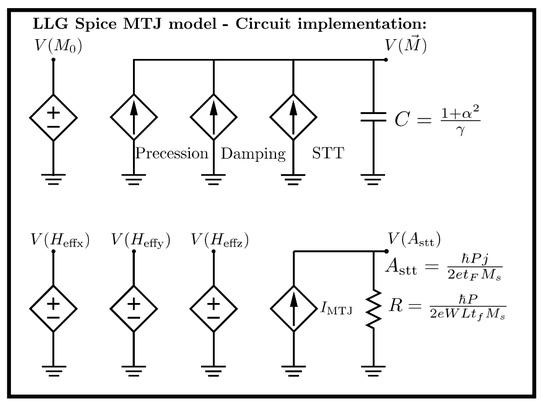
Methodology

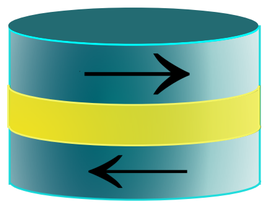


Results

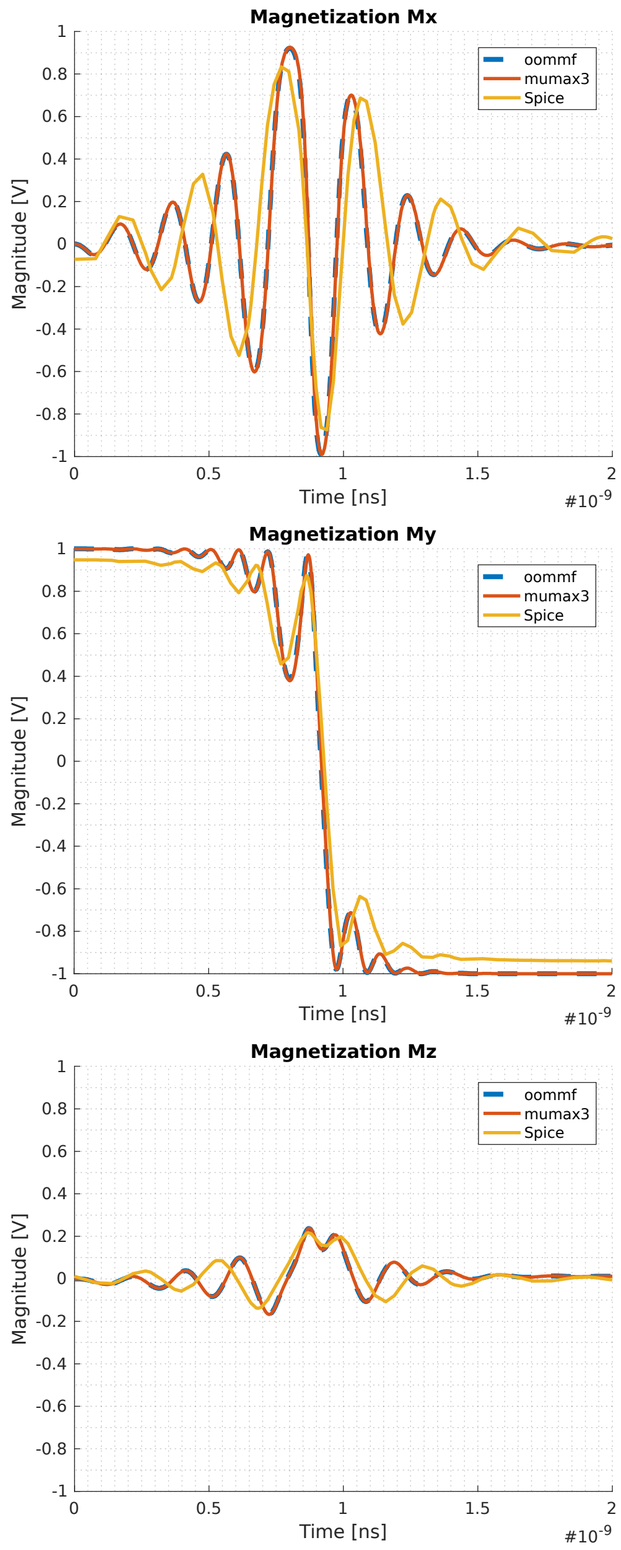








Parameter	Description	Value
Lx	**Free Layer Width**	160 [nm]
Ly	**Free Layer Length**	80 [nm]
Lz	**Free Layer Thickness**	5 [nm]
Msat	**Saturation Magnetization**	800e3 [A/m]
alpha	**Damping Factor**	0.01
Gamma_LL	**Gyromagnetic Ratio**	1.7595e11 [rad/Ts]
P	**Polarization Factor**	0.5669
Imtj	**Current Switching**	0.008 [A]
-	**Shape**	Elliptical



Conclusion

While less accurate, Spice simulations with compact models require lower computing power than micromagnetic simulations. For a single magnetic domain, though, the Macro Spice MTJ Model closely matches the results produced by the Mumax3 and Oommf simulator.

More Info

References

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[3] R. M. Brum and G. I. Wirth, "Magpdk: An open-source process design kit for circuit design with magnetic tunnel junctions," in Integrated Circuits and Systems Design (SBCCI), 2016 29th Symposium on.IEEE, 2016,pp. 1–6
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CNPq Conselho Nacional de Desenvolvimento Científico e Tecnológico

FAPERGS Fundação de Amparo à Pesquisa do Estado do Rio Grande do Sul