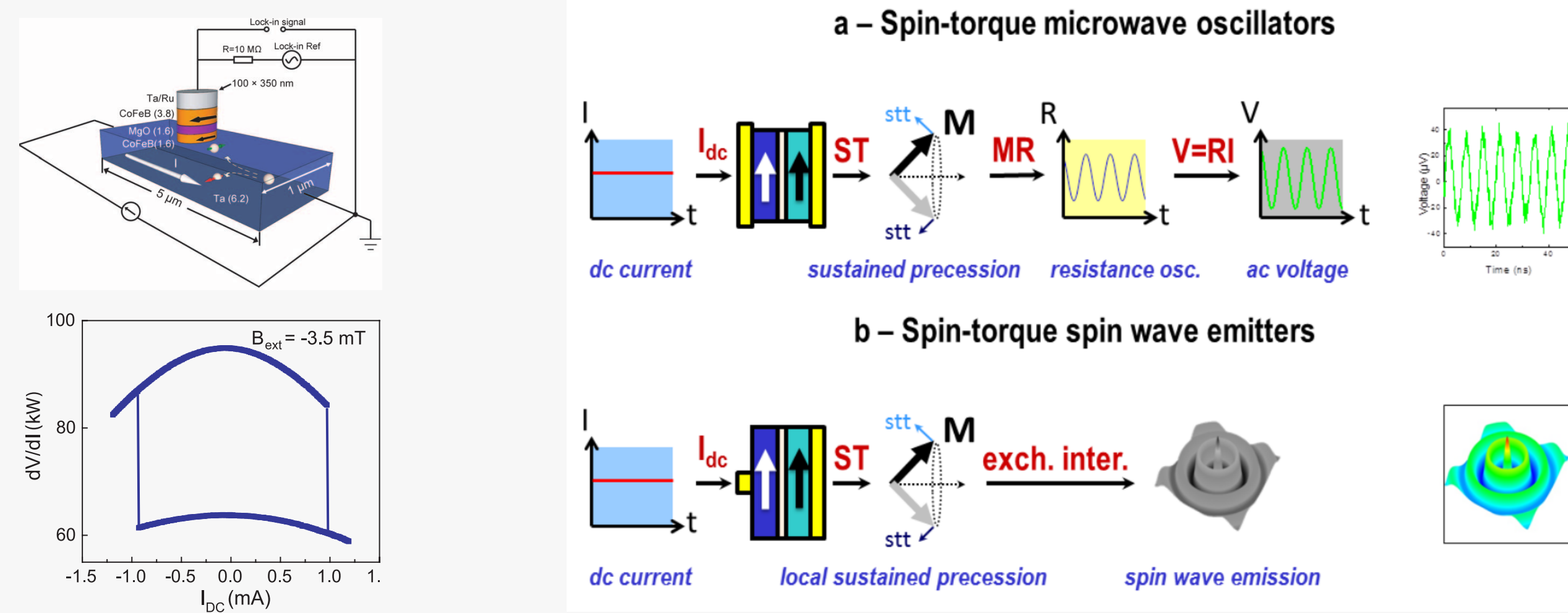


Electrical Detection of Direct and Alternating Spin Current Injected from a Ferromagnetic Insulator into a Ferromagnetic Metal

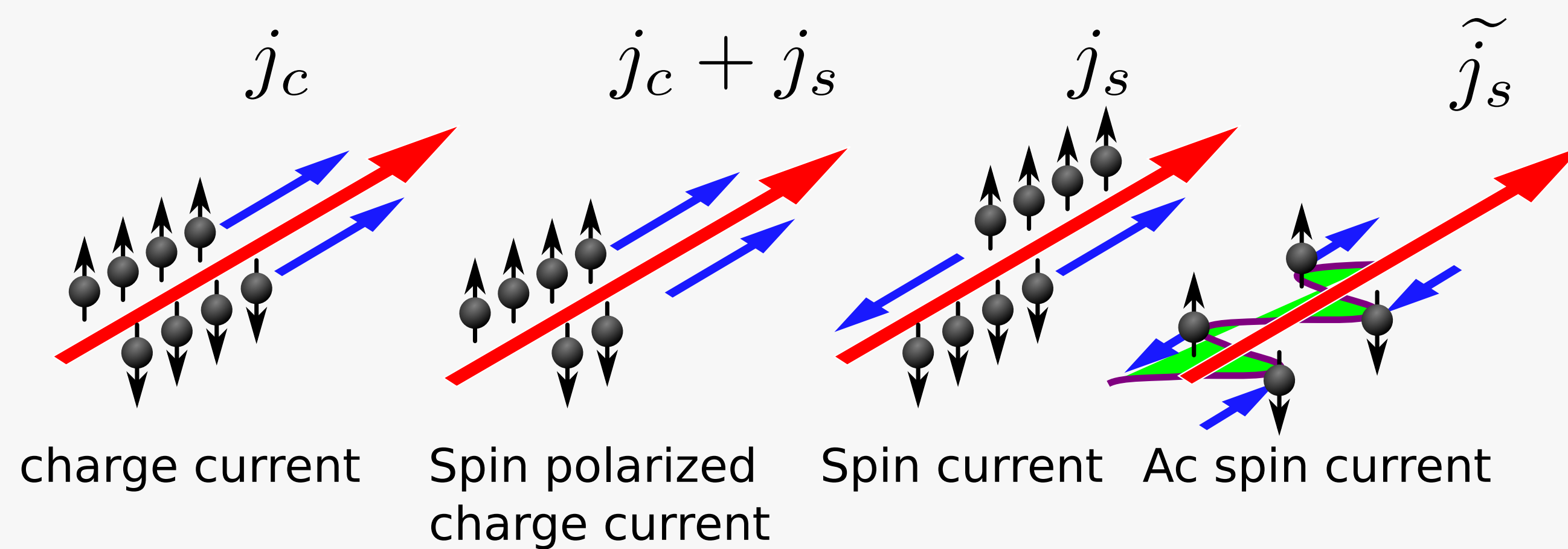
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Spin current and its applications

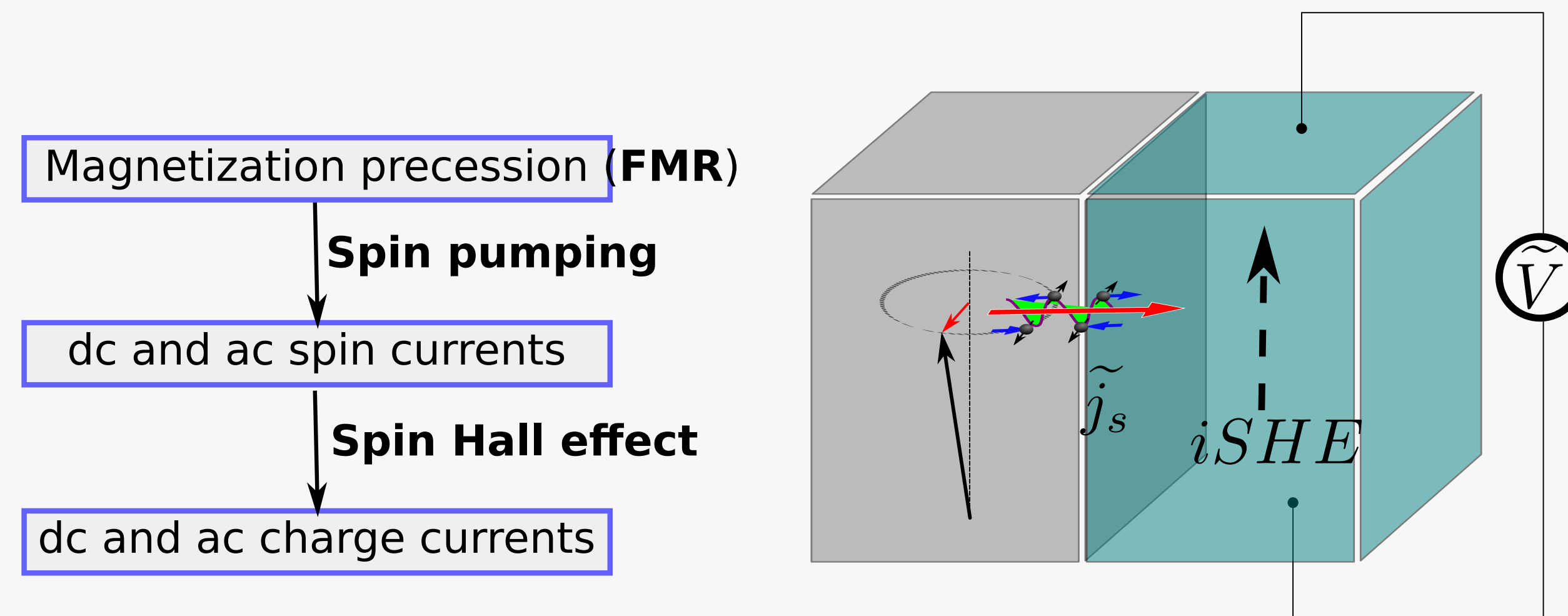
- 1 Switches magnetization to write information in memory device.
- 2 Drive magnetization precession to generate microwave.
- 3 Drives magnetization precession as spin wave emitter.



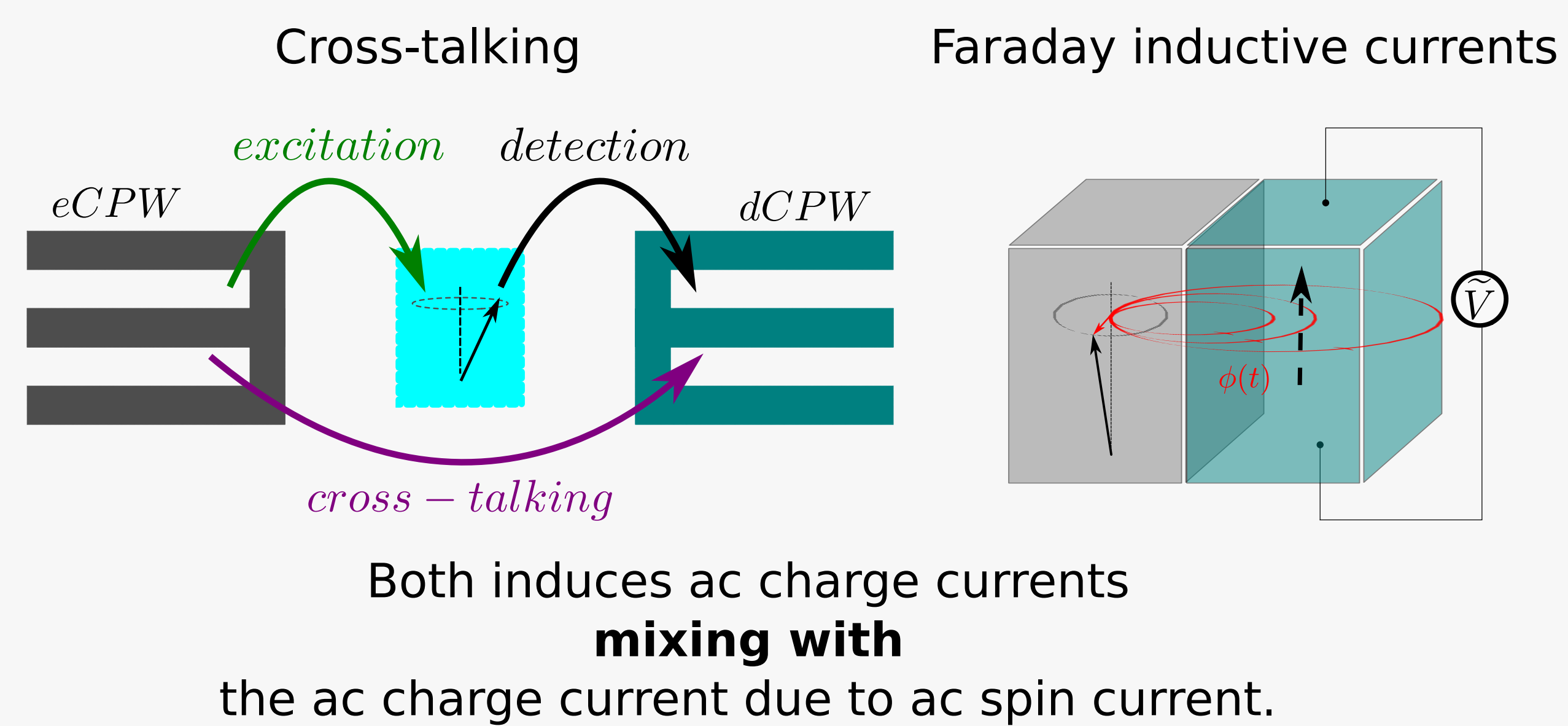
Ac spin current



Detection via iSHE

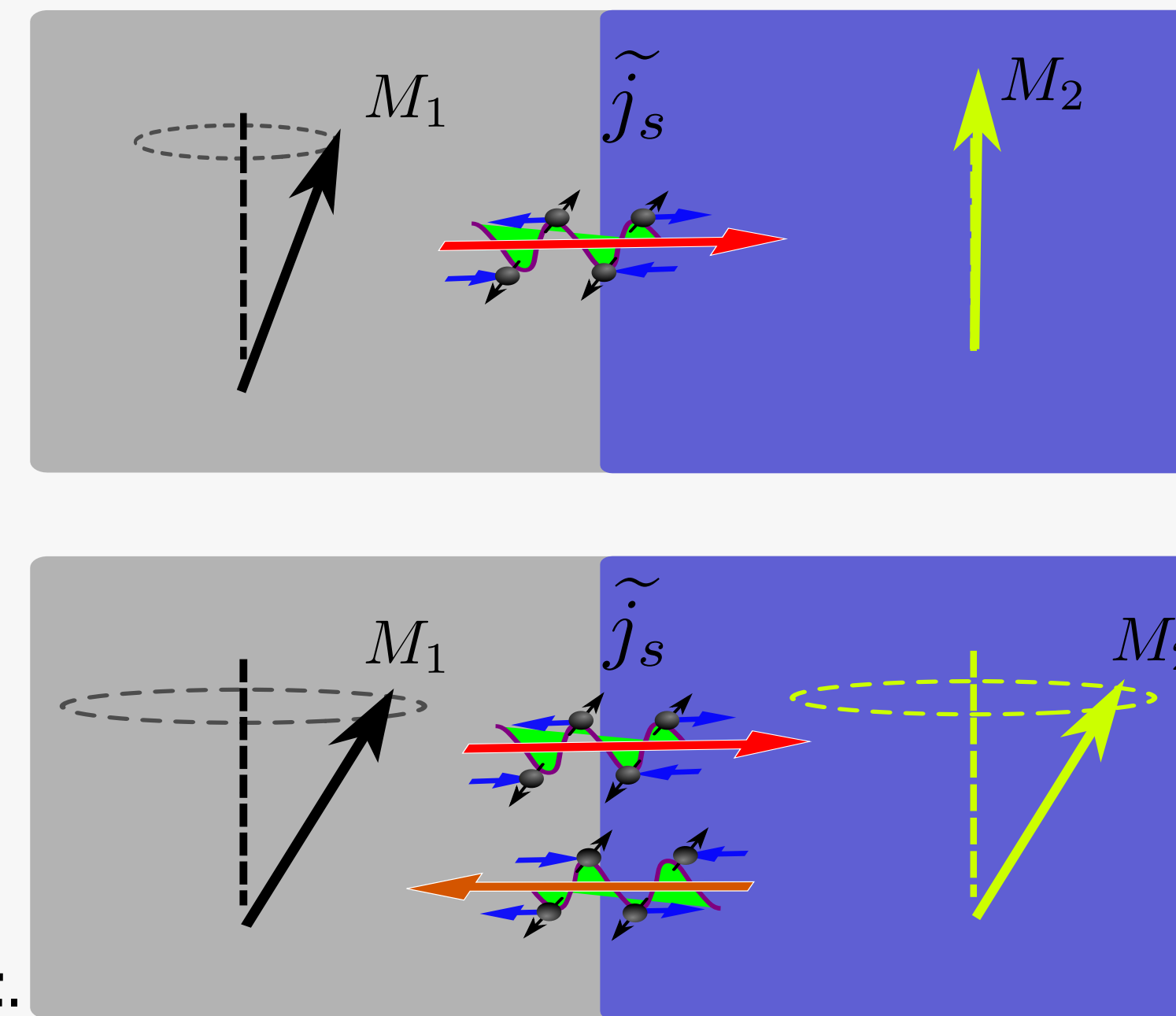


Challenges



Ac spin current as ac spin torque

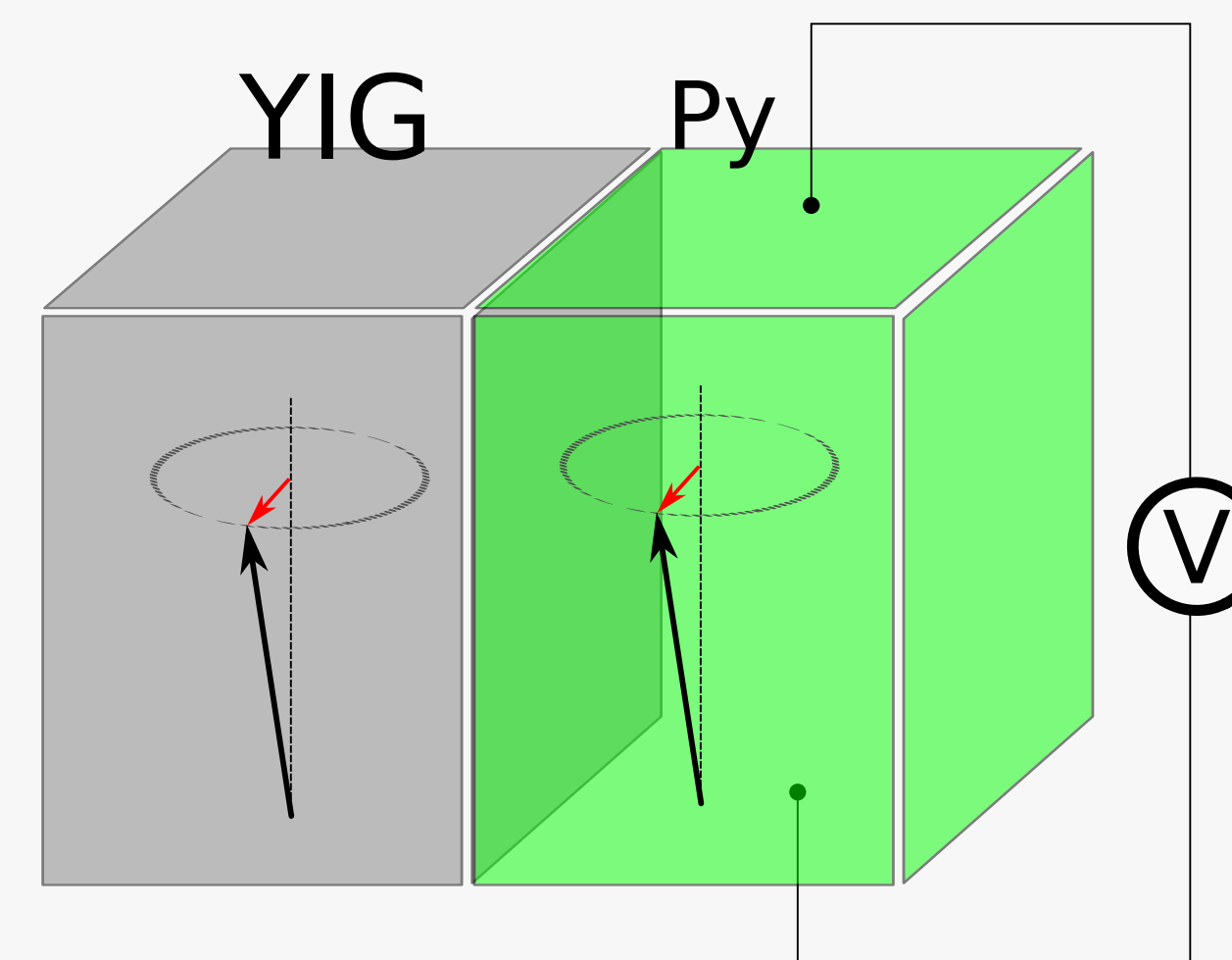
1. Spin current emitted by FMR as an additional damping reduces FMR amplitude.
2. Spin current acts on a magnetization as spin torque exciting precession.
3. The second FMR compensates the spin current leading to FMR amplitudes enhancement.



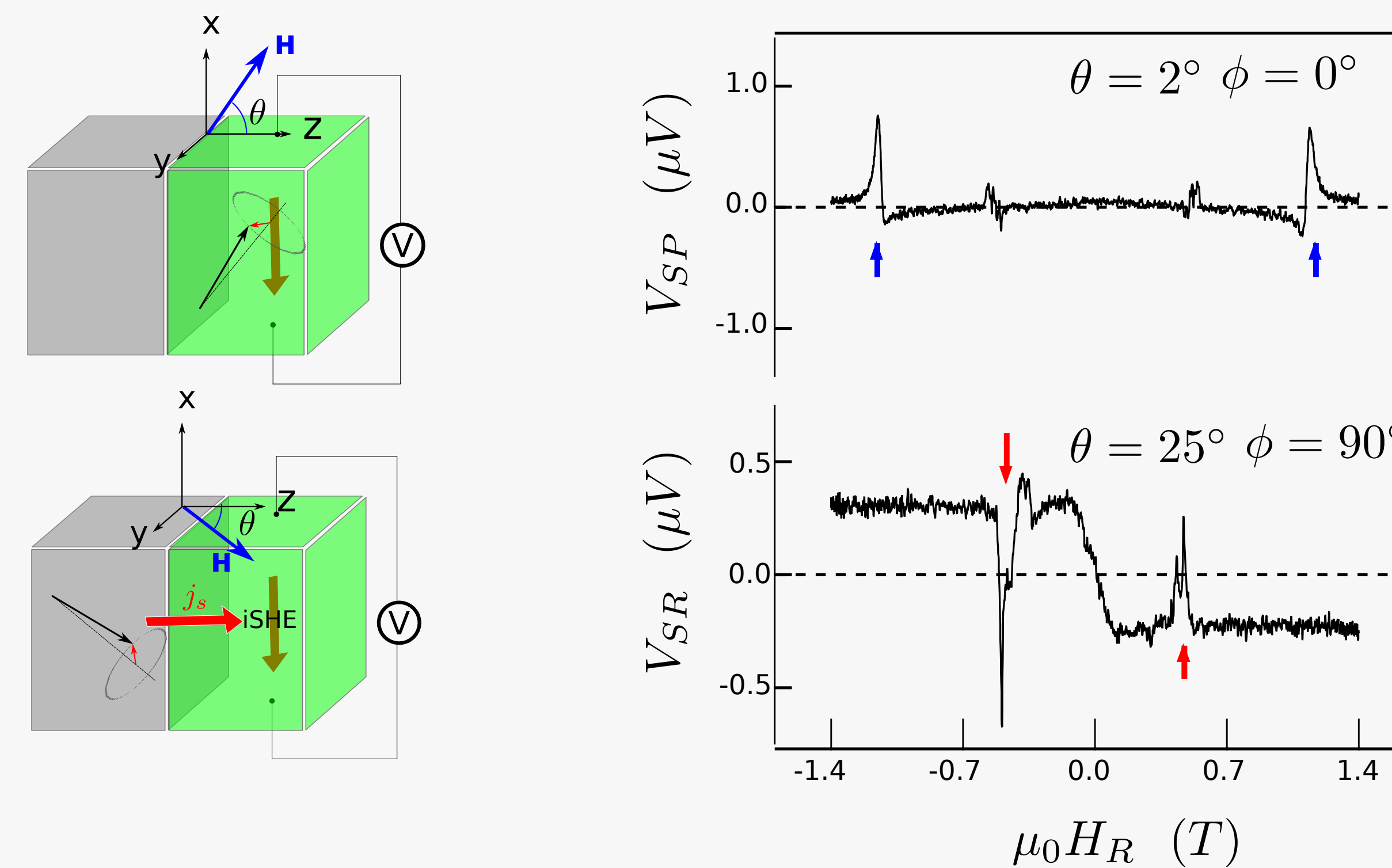
Ferromagnetic metal/Ferromagnetic insulator

Permalloy (Py)
 yttrium iron garnet (YIG)

Ferromagnetic metal (Py)
 Ferromagnetic insulator (YIG)

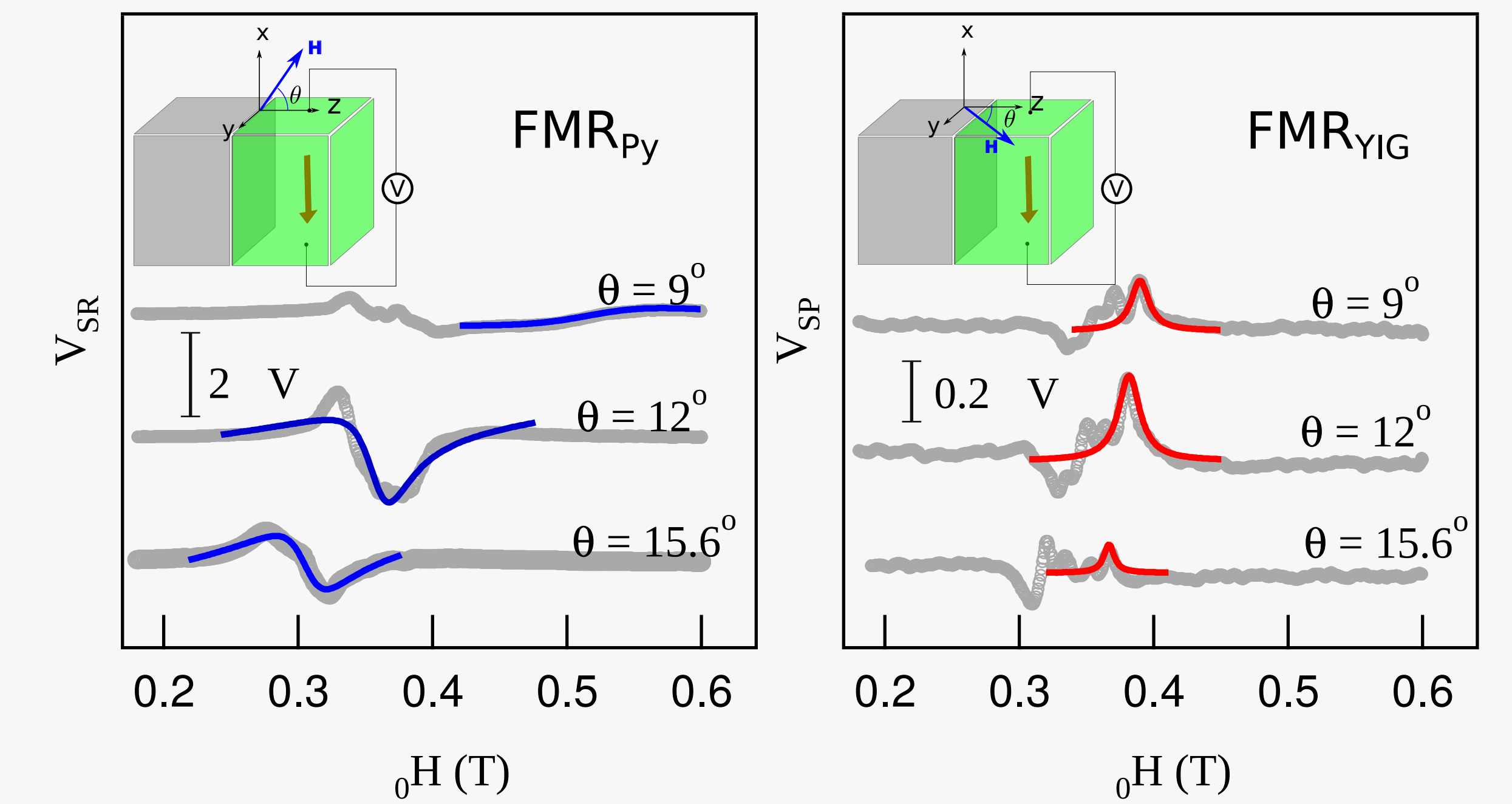


Detection FMRs from each layer separately



FMR in Py is detected as spin rectification by setting H field in x-z plane
 FMR in YIG is detected as spin pumping by setting H field in y-z plane

Spin dynamical coupling



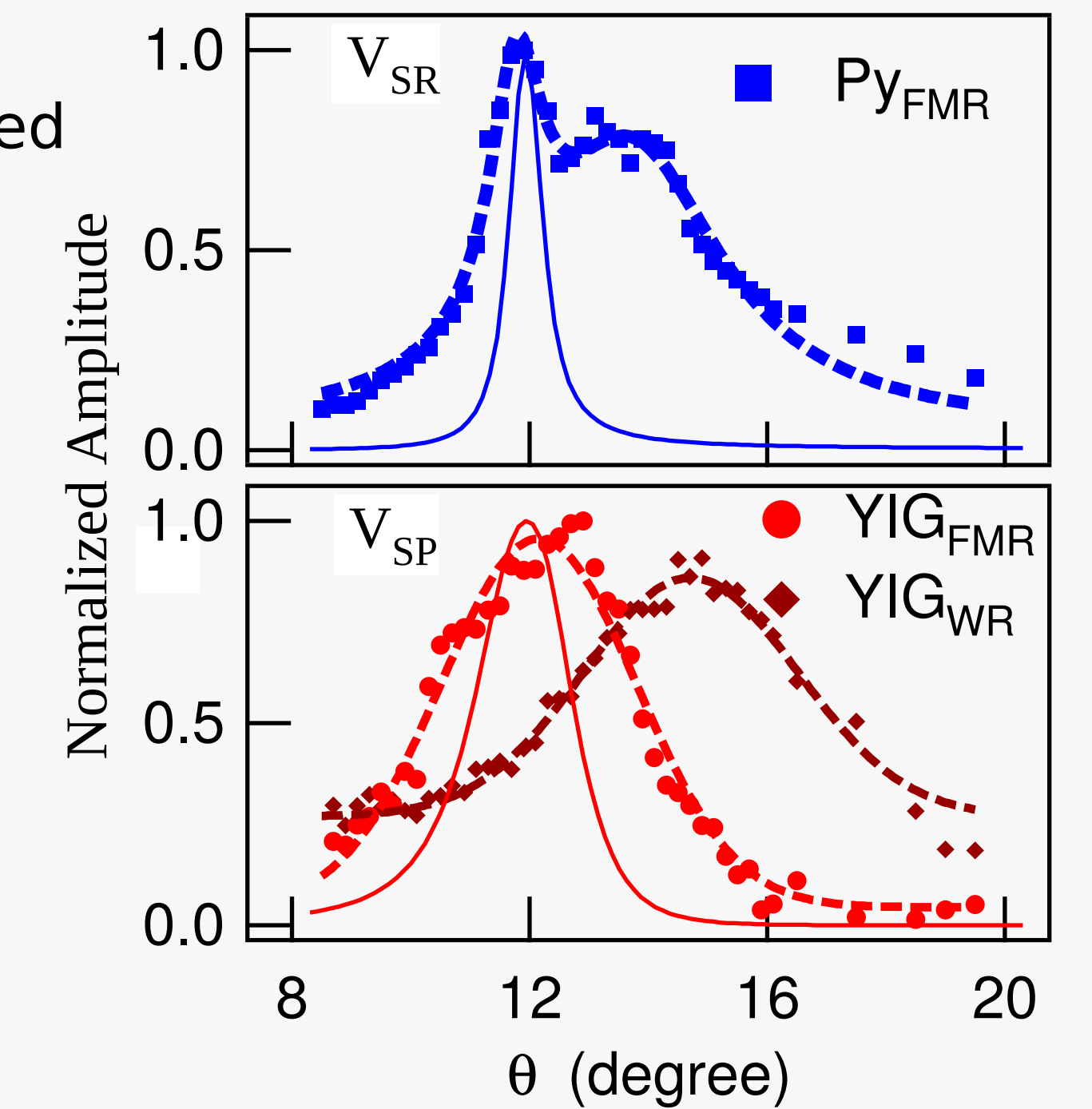
Features:

- 1 Both amplitudes are enhanced while both FMR ON $\theta = 12^\circ$.
- 2 The line width $\Delta\theta$ of YIG is broader than that of Py.

Ac spin torque calculation (solid lines)

$$V_{SR} \propto m_{Py} \propto \chi_{Py} \tau_{ac} \propto \chi_{YIG} h_{rf}$$

$$V_{SP} \propto m_{YIG}^2 \propto (\chi_{YIG} \tau_{ac})^2 \propto (\chi_{Py} h_{rf})^2$$



Conclusions

1. First dual ac spin current pumped experiment on a NEW FM/FI system (Py/YIG bilayer).
2. Detection of dc and ac spin current pumped by FMR in YIG via iSHE and spin dynamical coupling with Py.
3. Demonstration of ac spin current plays as a spin torque.

References

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