Sample outline template

**Format: 4 pages, ~15-16 para. Audience community: strongly correlated systems, oxide interface, spin-orbit coupling, nematic**

**Title:**

**Main Message:**

**Introduction**

* 1. The context -> limitations and gaps in the previous studies.
  2. Our questions -> our approach
  3. The road map

1. **Main section 1**
   1. Model (Fig)
   2. What we do
   3. What we find for one band.
   4. What we find for three band (Fig)
   5. We find no qualitative difference when including atomic SOC.
2. **Main section 2**
   1. What we do.
   2. What we find (Fig)
3. **Discussion & Conclusions** (Fig)

**Abstract:**

Why (context):

The question:

What we have done:

What we have found:

So what:

Sample outline v1

**Format: 4 pages, ~15-16 para.**

**Title (?) : origin of magnetic anisotropy in interface 2DEG**

**Main Message: A 2DEG with Rashba SOC at low densities shows an anisotropic spin-susceptibility leading to in-plane magnetization.**

**Introduction**

* 1. Context: The metallic interface between the insulators STO and LAO shows both, superconductivity and ferromagnetism.
  2. Question: Scanning squid microscopy measurements of the ferromagnetic state reveal magnetic puddles with in-plane magnetization. Such an anisotropy is expected from the broken mirror symmetry of the interface, but there is no explicit calculation explaining it yet.
  3. The road map (We first introduce the model and our method, then present the results for the susceptibility, explain how an in-plane magnetization naturally leads to an orbital ('nematic') order and finish with discussion & conclusion)

**Anisotropy in the in-plane vs. out-of-plane susceptibility**

**Coupling of orbital-order & in-plane fields**

**Discussion & Conclusions** (Fig)

**Abstract:**

Why (context):

The question:

What we have done:

What we have found:

So what:

Sample outline v2

**Format: 4 pages, ~15-16 para.**

**Title (?) : origin of magnetic anisotropy in interface 2DEG**

**Main Message: A 2DEG with Rashba SOC at low densities shows an anisotropic spin-susceptibility leading to in-plane magnetization.**

**Introduction**

* 1. The metallic interface between the insulators STO and LAO shows both, superconductivity and ferromagnetism.
  2. Scanning squid microscopy measurements of the ferromagnetic state reveal magnetic puddles with in-plane magnetization. Such an anisotropy is expected from the broken mirror symmetry of the interface, but there is no explicit calculation explaining it yet.
  3. outline of our paper (We first introduce the model and our method, then present the results for the susceptibility, explain how an in-plane magnetization naturally leads to an orbital ('nematic') order and finish with discussion & conclusion)

**Anisotropy in the in-plane vs. out-of-plane susceptibility**

* 1. Considering a parabolic band first (dxy), we see that the susceptibility has two terms, one that looks like a Pauli term and one that is like a van Vleck term...
  2. Looking at all three bands (i.e. adding the quasi-one-d ones), we find a window above the band edge of the q1d bands with anisotropic susceptibility (Fig of susc)
  3. We find no qualitative difference when including atomic SOC.

**Coupling of orbital-order & in-plane fields**

* 1. We find in-plane anisotropic spin-susceptibility due to coupling of nematic and fm order that is enhanced above dxz/dyz band edge (Fig)

**Discussion & Conclusions** (Fig)

**Abstract:**

Why (context): The question: What we have done:

What we have found: So what:

Sample outline v2.5

**Format: 4 pages, ~15-16 para.**

**Title (?) : origin of magnetic anisotropy in interface 2DEG**

**Main Message: A 2DEG with Rashba SOC at low densities shows an anisotropic spin-susceptibility leading to in-plane magnetization.**

**Introduction**

* 1. The metallic interface between the insulators STO and LAO shows both, superconductivity and ferromagnetism.
  2. Scanning squid microscopy measurements of the ferromagnetic state reveal magnetic puddles with in-plane magnetization. Such an anisotropy is expected from the broken mirror symmetry of the interface, but there is no explicit calculation explaining it yet.
  3. outline of our paper (We first introduce the model and our method, then present the results for the susceptibility, explain how an in-plane magnetization naturally leads to an orbital ('nematic') order and finish with discussion & conclusion)

**Anisotropy in the in-plane vs. out-of-plane susceptibility**

* 1. We consider a three-band model with Rashba SOC stemming from the Ti t2g orbitals at the interface. (Fig of disp & DOS)
  2. We calculate the bare spin-susceptibility for in-plane and out-of-plane fileds (defined through the grand potential of the system. )
  3. Considering a parabolic band first (dxy), we see that the susceptibility has two terms, one that looks like a Pauli term and one that is like a van Vleck term...
  4. Looking at all three bands (i.e. adding the quasi-one-d ones), we find a window above the band edge of the q1d bands with anisotropic susceptibility (Fig of susc)
  5. We find no qualitative difference when including atomic SOC.

**Coupling of orbital-order & in-plane fields**

* 1. To analyze the possibility of in-plane anisotropy due to orbital order, we analyze Landau free energy for nematic & fm order.
  2. We find in-plane anisotropic spin-susceptibility due to coupling of nematic and fm order that is enhanced above dxz/dyz band edge (Fig)

**Discussion & Conclusions** (Fig)

**Abstract:**

Why (context): The question: What we have done:

What we have found: So what:

Sample outline v3

**Title:  Origin of magnetic anisotropy in interface 2DEG**

**Main Message: A 2DEG with Rashba SOC at low densities shows an anisotropic spin-susceptibility leading to in-plane magnetization.**

1. **Introduction**
   1. (Problem statement) What is the mechanism of observed magnetization anisotropy and what are implications of the anisotropy.
   2. (method outlook) we address 1: itinerant electron system with Rashba-> calculate the spin susceptibility. 2: landau free energy and allowed coupling between fm & orbital order.
   3. Roadmap for the paper.
2. **Anisotropy in the in-plane vs. out-of-plane susceptibility**
   1. We consider a three-band model for the Ti t2g orbitals and focus on low denfity regime.
   2. Rashba SOC due to the interface. (Fig of disp & DOS) and its effect on band structure
   3. We calculate the bare spin-susceptibility for in-plane and out-of-plane fields by calculating grand potential in field and taking derivatives.
   4. For illustration, we analyze single parabolic band to show generically Rashba + band edge gives anisotropic susc.
   5. Looking at all three bands (i.e. adding the quasi-one-d ones), we find anisotropic susc in a window above the band edge of the q1d bands (Fig of susc)
   6. Discussion (& We find no qualitative difference when including atomic SOC)
3. **Coupling of orbital-order & in-plane fields**.
   1. Irrespective of mechanism for anisotropry, the existence of SOC couples orbital order and in-plane magnetization. For this purpose,  we analyze Landau free energy for nematic & fm order.
   2. We find in-plane anisotropic spin-susceptibility due to coupling of nematic and fm order that is enhanced above dxz/dyz band edge (Fig)
4. **Discussion & Conclusions** (Fig)
   1. We adress ... and find ...
   2. anisotropy.... mx / my -> orbital order

**Abstract:** The two-dimensional electron system found at the interface between SrTiO3 and LaAlO3 wasrevealed to exhibit ferromagnetism with moments preferable lying in plane. Apart from simplesymmetry arguments, the origin of this anisotropy is not well understood. In this work, we analyze the spin-susceptibility of a three-band model describing itinerant Ti 3d electrons with a Rashba spin-orbit coupling due to the lack of a mirror symmetry at the interface. For densities within the experimental range, we \_nd an anisotropic susceptibility favoring in -plane magnetization. Irrespective of the origin of the anisotropy, we also fnd a coupling of in-plane elds to orbital ordering ofthe quasi-one-dimensional bands leading to an additional in-plane anisotropy.