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Peer Review File

Skyrmionic Spin Structures in Layered Fe5GeTe2 Up To Room Temperature

Reviewers' comments:

Reviewer #1 (Remarks to the Author):

The authors report a skyrmionic spin structure near room temperature in a layered Fe_5GeTe_2 system. The Fe_5GeTe_2 system is a good candidate for spintronics in 2D materials due to its high Curie temperature and novelty spin texture. However, due to the complex Fe vacancy, stacking faults, and thermal history process, to date, its variable magnetic behavior is still not clear. The authors systematically studied the magnetic ordering and magnetic images for pre-cooling and post-cooling states by LTEM, magnetic measurement, and DFT calculation. The manuscript is clear and well-organized. In my opinion, it certainly merits publication in Communications Physics. However, I have a few questions that should be addressed before proceeding toward publication.
1) Why the skyrmionic bubbles can be stabilized at zero magnetic fields in Fig. 2d? How is the evolution of the spin texture when the field sweeps to the negative magnetic field? Are the skyrmionic bubbles in the Fe_5GeTe_2 system shown in Fig. 2d formed in the initial, nucleated, or annihilated state?
2) Following # 1), The M-T curve in Fig.3 exhibits a kink near 110 K at the post-cooling state, which may imply the existence of a phase transition. Did the authors observe any difference in the field-dependent magnetic images before and after phase transition? Perhaps the authors cannot cool the sample down to liquid helium temperature in their LTEM setup. It may be better to show field dependence of domain image for both states near the 77 K.
3) The Fe_5GeTe_2 shows different magnetic properties at the pre-cooling and post-cooling states. The structure of Fe_5GeTe_2 is an ABC stacking at the pre-cooling state. The stacking configuration can determine the magnetic ground state in vdW's materials. (Phys. Rev. Materials 4, 074008 (2020)) Is it a structural transition? Does the sliding of the sublayer induce this transition? It would be great if the author could exhibit the structural data (for example, XRD, the diffraction pattern of TEM, etc.) for both states.
4) The author claim that the magnetic ground state of pre-cooling Fe_5GeTe_2 is a ferrimagnetic, not a spin glass state. What does the M-H curve look like? It may benefit understanding the magnetic ordering if the authors can exhibit one MH curve between 87 K and 136 K in Fig4 (a) and (b).
5) In fig. 6, the author acquires the domain wall width by fitting the line profile of the contrast in the TEM image. I am not an expert in the EM community. I am just curious about whether the LTEM measurement configuration affects the analysis results of the domain wall width?
6) Pieces of literature on skyrmion and magnetic images of the closely related compound Fe_5GeTe_2 are insufficiently cited. For example, Phys. Rev. B 102, 064417 (2020), Physical Review Materials 6 (4), 044403(2022), Science Advances 8 (12), eabm7103 (2022) etc.

Minor comment:
Typo: Line 122 'it it found to be in a ferromagnetic state'

Reviewer #2 (Remarks to the Author):

The submitted manuscript reports the observations of spin structures and determined magnetic properties in the promising 2D vdW magnet Fe_5GeTe_2. Through Lorentz TEM, the authors observed magnetic bubbles in the flake which further concludes that Fe_5GeTe_2 exhibits an underlying centrosymmetry belonging to $R\bar{3}m$ space group. They also investigated the pre-cooling and post-cooling magnetic properties of Fe_5GeTe_2. Combined with DFT calculation, they proposed that Fe_5GeTe_2 might not be in a spin glassy state, but in a ferrimagnetic state while it is in the pre-cooling phase. The experimental data is very clear, the interpretation is insightful, the result of this manuscript is timely and will attract great attention of researchers in spintronics and 2D materials, so I recommend the publication in Communications Physics. There are several minor issues that the authors need to address before final publication:
1. In a recent paper (Physics Review Materials 3, 104401(2019)), the magnetic properties were

investigated in centrosymmetric magnet $Fe_{5-x}GeTe_2$, which represents a different phenomenon as reported in this study, especially for the M-T curve. Why?
2. Is this phenomenon was observed in one sample or more? The author should offer the magnetic properties with more samples. In Figure 4, the curves for the pre-cooling and for the post-cooling phase was shown with different temperatures, it's not convenient for readers.
3. As author mentioned, these magnetization curves are presented without taking into consideration of the demagnetization factor. However, the easy axis or easy plane is important for the represent study which is determined from the magnetization curves. The author should offer the evidence for this point instead of citing from other literatures. This related to my next question, if the spin prefers to align in the ab plane, with an application of external magnetic field, could magnetic bubbles generate?
4. The different types (Bloch or Néel) of skyrmions have been also reported in 2D vdW centrosymmetric magnet Fe_3GeTe_2, which is related to the thickness induced interface DMI. Does any similar possibility occur in the 2D vdW centrosymmetric magnet Fe_5GeTe_2? The author should discuss these with referencing the earlier studies (Adv. Funct. Mater. 2021, 2103583; Nano Lett. 2020, 20, 868−873). The authors should also consider the recent paper published by Yang Gao et al (Adv. Mater. 2020, 2005228)) reporting magnetic meron chain in the same material.
5. Minor comments
Type I magnetic bubble owes the clockwise and anticlockwise spin configuration, the author only drew a sketch of one in Figure 2c.
Whether it is or not the spin glassy state at 87K, the author might check this point by other methods, such as ac susceptibility measurement.

Reviewer #3 (Remarks to the Author):

This reports a very thorough study of topological spin structure in 2D van der Waals Fe_5GeTe_2 magnet at room temperature by experiment approach and density functional theory. The investigation of magnetic skyrmion has recently been a research frontier, and the results are of considerable interest, thus I recommend the current work to be published. But minor revision is needed, as listed below.

1). It has been reported that the effect of stacking fault on crystal symmetry in many materials. The authors should indicate the relation between them. Does and how stacking fault break spatial symmetry in this structure?

2) Actually, there are many ways in which skyrmion can be formed. In the first paragraph on page 4, how does the author determine that the stability of skyrmion originates from dipolar interactions after excluding DM interaction? Could the authors provide some explanation in their discussion?

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Date: 27th July 2022

Rebuttal Letter to the Reviewers

Dear reviewers,

We thank you for your positive responses and the opportunity to improve our manuscript. We used the comments to improve the quality of our manuscript and believe it is now ready for publication. Below, we have replied in detail to all the points raised. Furthermore, additional improvements to the manuscript have been made, which are listed at the end of this document.

Yours Sincerely,

Maurice Schmitt on behalf of all co-authors.

Reviewer: 1

Comments to the Author

The authors report a skyrmionic spin structure near room temperature in a layered Fe5GeTe2 system. The Fe5GeTe2 system is a good candidate for spintronics in 2D materials due to its high Curie temperature and novelty spin texture. However, due to the complex Fe vacancy, stacking faults, and thermal history process, to date, its variable magnetic behavior is still not clear. The authors systematically studied the magnetic ordering and magnetic images for pre-cooling and post-cooling states by LTEM, magnetic measurement, and DFT calculation. The manuscript is clear and well-organized. In my opinion, it certainly merits publication in Communications Physics. However, I have a few questions that should be addressed before proceeding toward publication.

We thank the reviewer for this very positive feedback regarding our manuscript and for the constructive changes suggested. Below please find the responses to all of these suggestions.

1) Why the skyrmionic bubbles can be stabilized at zero magnetic fields in Fig. 2d? How is the evolution of the spin texture when the field sweeps to the negative magnetic field? Are the skyrmionic bubbles in the Fe5GeTe2 system shown in Fig. 2d formed in the initial, nucleated, or annihilated state?

In the initially submitted manuscript we did not specify the magnetic field history of our sample in each image shown in Fig. 2d, even though it is important for the observed magnetic state. We have accordingly added an explanation on the history of the sample and why bubbles occur e.g. even at zero field in lines 119-127 of our updated manuscript. In short, the order in which the images in Fig. 2d were recorded is from left to right and then from top to bottom. In other words, first the lowest temperature was set, then a field from zero field up to the saturation field was applied, and then the next field sweep was done for the next higher temperature, and so on. Consequently, whenever an image at zero field is recorded, the sample was previously saturated along the positive field direction. That way, bubbles form while the field gradually sweeps from the previously applied saturation field and they remain stable even until an external field of zero is reached.

On the other hand, when no external fields are applied we have observed that stripe domains without preferred orientations form when the sample is cooled from room temperature to below the Curie temperature of the pre-cooling phase. This is because fields close to the saturation field have never been applied, which means bubbles have never been nucleated since the sample entered its magnetic phase. As such, if a field sweep to negative fields was done, we would expect a transformation from bubbles to stripe domains at moderately strong negative fields. However, the largest negative field achievable in our L-TEM setup is only -140mT, which is why only a field sweep for positive fields has been done.

2) Following # 1), The M-T curve in Fig.3 exhibits a kink near 110 K at the post-cooling state, which may imply the existence of a phase transition. Did the authors observe any difference in the field-dependent magnetic images before and after phase transition? Perhaps the authors cannot cool the sample down to liquid helium temperature in their LTEM setup. It may be better to show field dependence of domain image for both states near the 77 K.

In our current L-TEM setup it is unfortunately not possible to cool below 95K. However, we have included a direct comparison of the field-dependent magnetic images in the pre-cooling and the post-cooling phases at this lowest possible temperature of 95K. The results have been added to the manuscript in a newly added supplementary section S7.

3) The Fe5GeTe2 shows different magnetic properties at the pre-cooling and post-cooling states. The structure of Fe5GeTe2 is an ABC stacking at the pre-cooling state. The stacking configuration can determine the magnetic ground state in vdW's materials. (Phys. Rev. Materials 4, 074008 (2020)) Is it a structural transition? Does the sliding of the sublayer induce this transition? It would be great if the author could exhibit the structural data (for example, XRD, the diffraction pattern of TEM, etc.) for both states.

We have done separate XRD and L-TEM diffraction pattern measurements on a Fe_5GeTe_2 sample in order to show the structural nature of this phase transition. Indeed, both the XRD and L-TEM diffraction pattern results are significantly affected by the phase transition, indicating that the van der Waals stacking of our sample has changed. Explicitly, we have observed that the XRD peaks associated with the c-axis have shifted, and have directly imaged stacking faults, which occured after the phase transition. These results are discussed further in our new supplementary section S8.

4) The author claim that the magnetic ground state of pre-cooling Fe5GeTe2 is a ferrimagnetic, not a spin glass state. What does the M-H curve look like? It may benefit understanding the magnetic ordering if the authors can exhibit one MH curve between 87 K and 136 K in Fig4 (a) and (b).

We have coincidentally not previously measured any M-H curves in the interesting regime of 87K to 136K in the pre-cooling phase, i.e. where the magnetization decreases with decreasing temperature. However, it is a valuable suggestion to measure an M-H curve in this regime, and we have added a new curve corresponding to a temperature of 120K to Fig. 4(a). This M-H curve is in line with all other curves and does not exhibit any particular behavior, which supports our finding that Fe_5GeTe_2 is not in a spin glassy state. We have added a remark about this point in lines 190-196.

5) In fig. 6, the author acquires the domain wall width by fitting the line profile of the contrast in the TEM image. I am not an expert in the EM community. I am just curious about whether the LTEM measurement configuration affects the analysis results of the domain wall width?

In the measurement configuration we used to record the images from which the domain wall profiles have been extracted, the accuracy is adequate. We used off-axis electron holography, from which the domain wall profiles can directly be extracted. However, if we took Fresnel defocus images for this purpose instead, then we would have to comprehensively calibrate the setup and run computationally involved analyses in order to extract an accurate profile. Since this is not obvious and we initially did not mention this detail, we have briefly explained this circumstance in lines 264-268 in our revised manuscript.

The technical background here is as follows: Fresnel defocus imaging generally is the most common LTEM technique for magnetic imaging. The image is acquired in a defocused plane to observe variations of contrast produced by the deflections of the electron beam when passing through in-plane magnetic fields. With this technique, the domain wall width cannot be measured directly because the magnetic contrast is delocalized. To overcome this problem, we used off-axis electron holography instead. There, the principle is to record an in-focus interference pattern using an electron biprism. From this pattern, we can map the phase of the electron wave, which is related quantitatively to the B field integrated over the electron beam direction. In this case, the domain wall width can be measured directly because the image is in-focus. This was achieved by fitting the profile of the phase gradient at the domain wall with a tanh function.

6) Pieces of literature on skyrmion and magnetic images of the closely related compound Fe5GeTe2 are insufficiently cited. For example, Phys. Rev. B 102, 064417 (2020), Physical Review Materials 6 (4), 044403(2022), Science Advances 8 (12), eabm7103 (2022) etc.

We thank the reviewer for providing additional and relevant literature to consider in our manuscript. We have cited *Phys. Rev. B 102, 064417 (2020)* as part of our introduction of the material Fe_5GeTe_2. We have also added a brief remark on the closely related and interesting material $(Fe_{0.5}Co_{0.5})_5GeTe_2$ while citing the suggested literature *Physical Review Materials 6 (4), 044403(2022)* and *Science Advances 8 (12), eabm7103 (2022)*. These changes can be seen in lines 6-9 of our updated manuscript.

Minor comment:
Typo: Line 122 'it it found to be in a ferromagnetic state'

5

We thank the reviewer for pointing out this typo, which went unnoticed by us. We have fixed this typo in line 144.

Reviewer: 2

Comments to the Author
The submitted manuscript reports the observations of spin structures and determined magnetic properties in the promising 2D vdW magnet Fe5GeTe2. Through Lorentz TEM, the authors observed magnetic bubbles in the flake which further concludes that Fe5GeTe2 exhibits an underlying centrosymmetry belonging to R3̅m space group. They also investigated the pre-cooling and post-cooling magnetic properties of Fe5GeTe2. Combined with DFT calculation, they proposed that Fe5GeTe2 might not be in a spin glassy state, but in a ferrimagnetic state while it is in the pre-cooling phase. The experimental data is very clear, the interpretation is insightful, the result of this manuscript is timely and will attract great attention of researchers in spintronics and 2D materials, so I recommend the publication in Communications Physics. There are several minor issues that the authors need to address before final publication:

We thank the reviewer very much for the positive feedback and the recommendation for publication of our manuscript. We have responded to all your points in full below.

1. In a recent paper (Physics Review Materials 3, 104401(2019)), the magnetic properties were investigated in centrosymmetric magnet Fe5-xGeTe2, which represents a different phenomenon as reported in this study, especially for the M-T curve. Why?

The cited study by May et al. thoroughly characterizes the magnetic properties of Fe_5GeTe_2, both before and after the irreversible phase transition which occurs upon cooling down to about 100K for the first time. Furthermore, they compare annealed and quenched samples in each measurement, showing vastly different properties.

In our manuscript, a quenched sample has been used. A direct comparison between May's and our in-plane M-T curve for a quenched sample can be seen in Fig. R1 below. The M-T curves show good qualitative agreement, with both exhibiting a maximum upon first cooling at around 150K, a sharp increase upon the phase transition at just below 100K, and a curve more closely resembling the behaviour expected for a ferromagnet afterwards. The observed slight quantitative disagreements might occur due to the different magnitude of applied fields, application of the in-plane field in a different direction, or a different sample purity. In particular, the fact that the peak upon first cooling at around 150K is closer to the saturation magnetization than in May's measurements could be attributed to the higher applied field (0.1T vs. May's 0.01T).

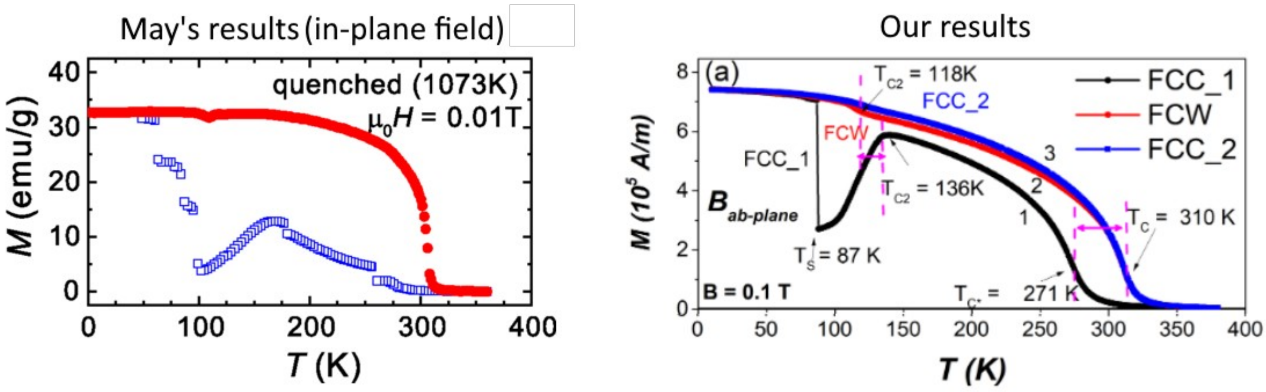

Fig. R1: M-T curves of quenched Fe_5GeTe_2 measured with an applied in-plane field. May's results on the left are qualitatively similar to our results on the right. Slight quantitative disagreements could be attributed to differences between the samples or experimental setups.

2. Is this phenomenon was observed in one sample or more? The author should offer the magnetic properties with more samples. In Figure 4, the curves for the pre-cooling and for the post-cooling phase was shown with different temperatures, it's not convenient for readers.

The characteristic M-T behaviour has been observed in two independent samples. For example, the results shown in Fig. 3a) and Fig. 3b) in the manuscript correspond to two different samples. This has not been pointed out very clearly in our manuscript, so we have made changes to the manuscript in lines 171-174 to mention this important point clearly and explicitly. Furthermore during the development of the Fe_5GeTe_2 crystals we have analyzed dozens of samples and found consistent results.

Notably, in both panels (i.e. for both samples) in Fig. 3 in the manuscript we observe a peak in the magnetization during first cooling (FCC_1) at around 150K, a first-order phase transition just below 100K and finally behavior, which more closely resembles the M-T curve expected for a ferromagnet.

We have noted that the 180K and 220K M-H curves initially shown in Fig. 4 are unique to panel (a) but are represented by the same colors as other temperatures in the other panels, and as such can be confusing when compared to the curves shown in other panels. Consequently, we have updated panel (a) in figure 4 with additional data, which is in line with panels (b-d). We have also added a completely new curve corresponding to 120K and used a unique color for it, as it does not occur in any other panel.

3. As author mentioned, these magnetization curves are presented without taking into consideration of the demagnetization factor. However, the easy axis or easy plane is important for *the represent study which is determined from the magnetization curves. The author should offer the evidence for this point instead of citing from other literatures. This related to my next question, if the spin prefers to align in the ab plane, with an application of external magnetic field, could magnetic bubbles generate?*

We have presented both SQUID and direct L-TEM imaging results in order to examine the anisotropy of Fe_5GeTe_2, but were not very clear about how we can draw robust conclusions. In the supplementary section S1, we show that direct L-TEM imaging reveals that the c-axis of Fe_5GeTe_2 is the preferred axis for the magnetization. While SQUID measurements can be misleading when the demagnetization factor is not considered, the imaging we present is a direct observation that the c-axis is the easy axis in Fe_5GeTe_2, because L-TEM measurements are not affected by the demagnetization factor. Thus, we have added a short discussion in lines 15-18 in the supplementary information stating that the L-TEM results are more robust than the SQUID results without demagnetization considerations.

4. The different types (Bloch or Néel) of skyrmions have been also reported in 2D vdW centrosymmetric magnet Fe3GeTe2, which is related to the thickness induced interface DMI. Does any similar possibility occur in the 2D vdW centrosymmetric magnet Fe5GeTe2? The author should discuss these with referencing the earlier studies (Adv. Funct. Mater. 2021, 2103583; Nano Lett. 2020, 20, 868−873). The authors should also consider the recent paper published by Yang Gao et al (Adv. Mater. 2020, 2005228)) reporting magnetic meron chain in the same material.

The literature the referee cited is intriguing. We have briefly discussed and cited the paper *Adv. Mater. 2020, 2005228* in our introduction in lines 21-23 and the paper *Nano Lett. 2020, 20, 868−873* in line 19. While further studies similar to *Adv. Funct. Mater. 2021, 2103583* on Fe_5GeTe_2 heterostructures would be interesting, they go beyond the scope of this work. However, we have mentioned the possibility for such further studies as an outlook in our conclusions in lines 329-333.

While on the topic of skyrmion types, we have added a brief remark on the types we observe in our experiments in lines 98-103, and also in the conclusions. We exclusively observe Bloch-type bubbles, which is an indication that there is no strong interfacial DMI present in our system specifically.

5. Minor comments
Type I magnetic bubble owes the clockwise and anticlockwise spin configuration, the author only drew a sketch of one in Figure 2c.
Whether it is or not the spin glassy state at 87K, the author might check this point by other methods, such as ac susceptibility measurement.

9

It is indeed helpful to show both possible bubble chiralities in Fig. 2c). We have updated the figure accordingly.

We have measured additional M-H curves in the regime of 87K to ~130K in the pre-cooling phase in order to check if the material is in a spin glassy state with another independent method. The M-H curve at 120K is now shown in Fig. 4 and it does not deviate from the expected behavior based on all other M-H curves, which indicates that Fe_5GeTe_2 is not in a spin glassy state. Additional measurements using techniques that are not available in our group could be done but given the existing clear evidence, we do not want to protract the publication of our work unnecessarily, which would invariably be the case if we were to set up a collaboration for further measurements not possible on-site.

Reviewer: 3

Comments to the Author
This reports a very thorough study of topological spin structure in 2D van der Waals Fe5GeTe2 magnet at room temperature by experiment approach and density functional theory. The investigation of magnetic skyrmion has recently been a research frontier, and the results are of considerable interest, thus I recommend the current work to be published. But minor revision is needed, as listed below.

Firstly we thank the referee for the constructive comments, that helped us to further improve our manuscript and also will help the reader to better understand and appreciate our results. We have considered carefully the valid points raised and we have responded by extensive further analysis eliciting the underlying physical processes.

1). It has been reported that the effect of stacking fault on crystal symmetry in many materials. The authors should indicate the relation between them. Does and how stacking fault break spatial symmetry in this structure?

Indeed, illustrating the stacking properties in Fe5GeTe2 is vital, as there is a significant change in the stacking when the irreversible phase transition occurs. To this end, we have carried out extensive additional XRD and L-TEM diffraction pattern measurements in order to illustrate how the c-axis is affected by the phase transition. We found that the stacking is significantly affected as the c-axis expands during the phase transition, which the XRD results suggest. Furthermore, we show L-TEM images and diffraction patterns, which directly show the occurrence of stacking faults after the phase transition. These results are presented in the new supplementary section S8.

Concerning symmetry breaking induced by stacking faults, we have initially observed stacking faults near the surface of our bulk samples (up to approximately 200nm), as discussed in the manuscript. But the lamella used in the L-TEM imaging of the magnetic bubbles, from which we infer the crystal structure, was cut such that these faults near the surface of the bulk material are not included. As such, we do not expect any spatial symmetry breaking due to stacking faults in these images. We initially did not explicitly state this important point in our manuscript, but we have added a short discussion in lines 105-110 in our revised manuscript.

As discussed, we have directly observed the occurrence of stacking faults, even in an L-TEM lamella, after the phase transition. However, our discussion of the crystal symmetry is limited to the pre-cooling phase. As such, stacking faults are not expected to affect our analysis regarding the crystal symmetry.

2) Actually, there are many ways in which skyrmion can be formed. In the first paragraph on page 4, how does the author determine that the stability of skyrmion originates from dipolar interactions after excluding DM interaction? Could the authors provide some explanation in their discussion?

In the originally submitted manuscript we only provided information which supports the conclusion that the bubbles are not stabilized by DMI. However, we have done additional DFT calculations in order to support the point that the bubbles are stabilized by dipolar interaction.

In the newly added supplementary section S6, we present DFT results which show the obtained exchange interaction parameters J_{ij} and DMI parameters D_{ij} based on the distance between the spin sites. Firstly, it can be seen that DMI is generally weak in Fe_5GeTe_2, which is in line with the observation that bubble chiralities occur in the L-TEM images. Furthermore, the shown significant J_{ij} values are all positive, such that a stabilization of these magnetic bubbles due to frustration is unlikely.

Further stabilizing mechanisms, such as four-spin interactions, generally occur rarely. While we do not have any data, which directly allows us to exclude these interactions, we deem it unlikely that they are the source of stabilization of the bubbles observed in our manuscript.

Thus, the dipolar interaction on the other hand remains the most likely candidate for the stabilization mechanism, since it is both generally more common, but also strong in our system considering the relatively large size of the observed bubbles (radii up to about 100 nm).

In any case, we recognize that our original wording gives the impression that we are very confident that all stabilization mechanisms except the dipolar interaction can be excluded. However, even with these additional DFT results, we cannot exclude other stabilization mechanisms with certainty. Thus, we changed the wording in the main manuscript in lines 98-101 in order to express that we think the dipolar interaction is not the certain, but the most likely stabilization mechanism

Beyond the referees' constructive suggestions, we have further improved the manuscript in the meantime. A list of these independent changes is as follows:

Main manuscript:
- Abstract: Improved the clarity of the wording in the abstract, mentioning spin-model calculations in addition to DFT calculations explicitly
- line 33: Changed 'irreversible first-order phase transition' to 'irreversible phase transition'. The order of the phase transition is not relevant to the main points of our manuscripts. As such, we deemed it would be better to remove the claim concerning the order of the phase transition.
- lines 46-48: At the end of the introduction, we initially mentioned that we determine 'whether Fe_5GeTe_2 is in a spin glassy state or not', without mentioning the final results there. This has been changed, such that our result that Fe_5GeTe_2 is not in a spin glassy state is clearly stated.
- line 75 & caption of Fig. 2: Our wording did not make it perfectly clear in which phase the measurements in Fig. 2 were taken. We have changed this by explicitly stating that they were done in the pre-cooling phase.
- lines 199: In the main text, we have explicitly stated that the field is applied along the c-axis for clarity.
- equation 8: inserted the divergence of the normalized magnetization *m* instead of defining further notation.

Supplementary Information:
- lines 71-73: We briefly elaborate on the approximation involved when using the Heisenberg model for Fe_5GeTe_2.
- lines 82-83: We clearly stated that r_{ij}^2 is averaged, rather than r_{ij}.
- lines 102-103: We added and changed some references.
- lines 104-118: We have rewritten parts of section S4.

Once more we would like to thank the referees for thoroughly reading our manuscript. We believe that these changes have further improved the quality and readability of our manuscript. We henceforth resubmit to Communications Physics for review.

Yours Sincerely,

Maurice Schmitt on behalf of all co-authors.

REVIEWERS' COMMENTS:

Reviewer #1 (Remarks to the Author):

I believe the authors have adequately addressed my concerns. Therefore, I recommend the manuscript for publication.

Reviewer #2 (Remarks to the Author):

The authors have addressed the concerns properly. With the revision, it is ready for publication.

Reviewer #3 (Remarks to the Author):

I am satisfied with the response made by the authors.