Reviewer's report

Title: Signal Encoding in Magnetic Particle Imaging: Properties of the System Function

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Reviewer: Anant Madabhushi

Reviewer's report:

Magnetic particle imaging (MPI) is a new tomographic imaging technique that images magnetic tracer material. This paper concerns the establishment of a theoretic framework for describing its “system function” (i.e. transfer function). The system function is necessary for inferring particle density information from the coil voltages. Currently, the system function is determined empirically, resulting in a noisy, complex, and time-consuming procedure. The authors suggest that an analytically derived system function will be a step toward mitigating many of these disadvantages.

In general the paper is very well written. Though the mathematics is quite involved, it is not too difficult to follow in most places. The premise that an exploration of the mathematics describing MPI is valuable, is reasonable.

I do have several comments/suggestions that may improve the understandability of the paper:

1) Though it may be implicit, I would suggest defining the spatial component r.

2) There seems to be many quantities defined by the letter “s”. Is this to imply they are related? Specifically, is coil sensitivity related to the signal? Also, some explanation of the connection between the signal s and the voltage V would be helpful. Are these not the same?

3) FOV is never defined. I assumed you meant field of view.

4) Is this sentence true: “If the gradient is non-zero over the complete FOV, the selection field can only be zero in a single point (page 4)” It seems like this should be always positive (or always negative).

5) This sentence portion—“If the particle concentration exceeds this range (page 7)”—is confusing to me. Does this mean that particles contributing to the concentration fall outside the interval?

6) Though the paper states that: “From figure 6 it is clear that spatial encoding over the full extension of the FOV cannot be achieved using a 1D FFP motion,” it was not clear to me. Also, a brief introduction to the Lissajous pattern would be helpful. In general, the extension from 1 to 2(3) dimensions was confusing to me. Perhaps a little more intuition would be helpful, especially as to why multiple harmonic drive fields are necessary.

I also have two general suggestions:

1) It would be nice if the introduction better introduced MPI and provided an
intuitive feel as to the problem. I found that I needed to consult the previous papers to understand the basic idea. However, I think it would be possible to include this idea with little added material. Since the paper lacks any physical results, this would provide helpful intuition into the problem you are addressing.

2) It would be helpful if your conclusions were tested in a real example, but perhaps this is too difficult at the moment. Unfortunately, without these examples it’s hard to really know if your results can accomplish the stated goals with respect to image reconstruction.

**Level of interest:** An article of importance in its field

**Quality of written English:** Acceptable

**Statistical review:** No, the manuscript does not need to be seen by a statistician.

**Declaration of competing interests:**

I declare that I have no competing interests