

MATMED

**Mathematical and computational methods
for co-registering
multi-modal medical images**

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Centre of Mathematics for Applications**

Contents

- Project trivia
- What is image registration?
- What are we going to do?

Partners

- The Interventional Centre, Rikshospitalet University Hospital in Oslo
- Centre of Mathematics for Applications (CMA), University of Oslo
- Image processing group (BBG), Department of Mathematics, University of Bergen,

Principal investigators

- *Eigil Samset*, Interventional Centre (project leader)
- *Xue-Cheng Tai*, Department of Mathematics, University of Bergen
- *Knut Mørken*, Department of Informatics and CMA, University of Oslo
- In addition there are 9 named national and international collaborators

Collaborators

- University of Oslo and Simula Research Lab (Albregtsen, Hjelle, Reimers)
- University of Bergen (Lundervold, Zanna Munthe Kaas)
- Harvard Medical School (Kikinis)
- University of California, Los Angeles (Chan, Osher)
- University of Saarland (Weickert)

Resources

- Approximately 2 000 000 NOK pr. year
- Will support 3 PhD-students
- 2 PhD-students hired already
- 3rd will be hired before the summer

Motivation for image registration

- Information about a patient is often obtained via several imaging techniques
- Different techniques reveal different features
- Some techniques are useful for pre-operative imaging, others can be used during surgery

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Motivation for image registration

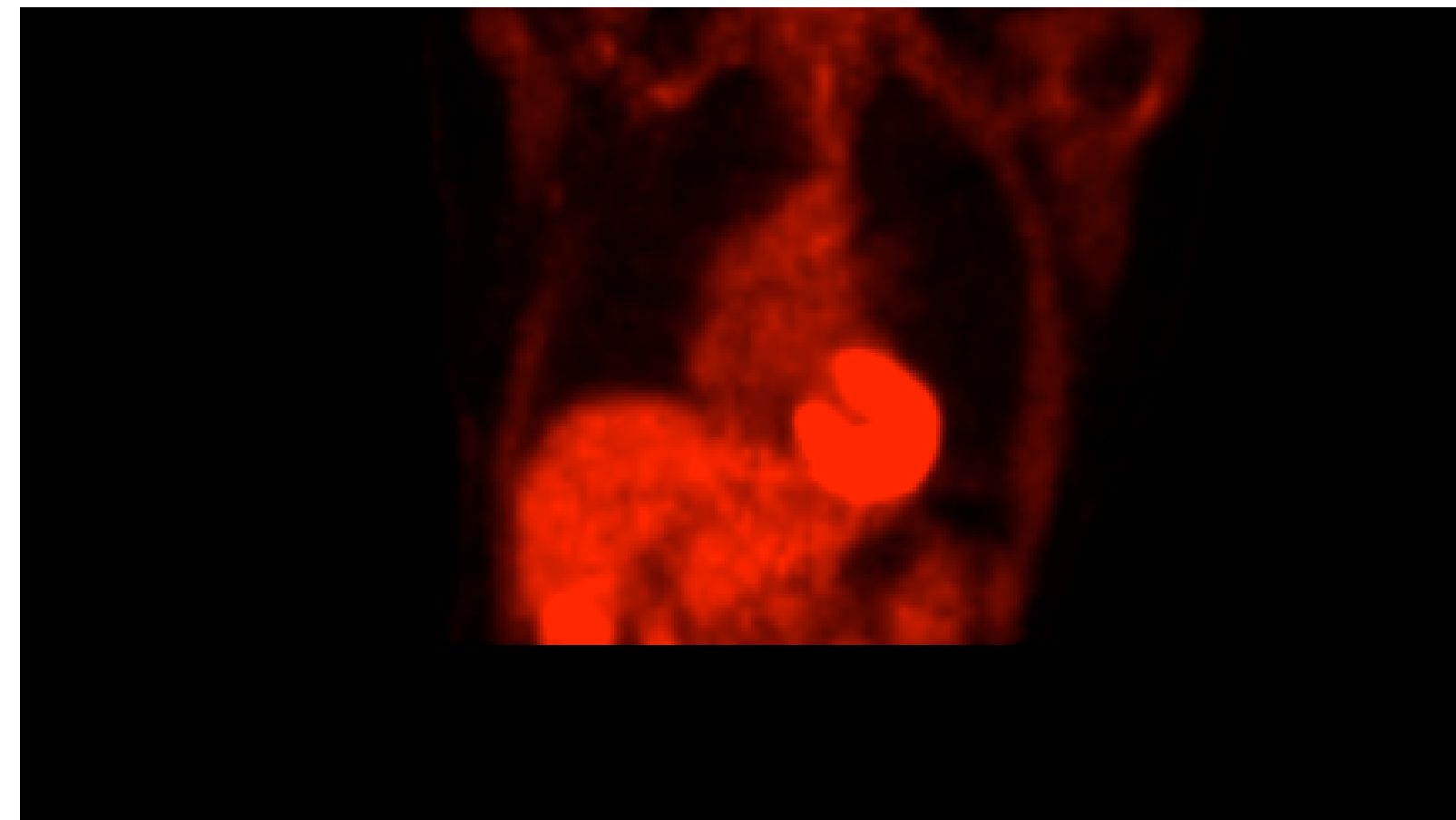
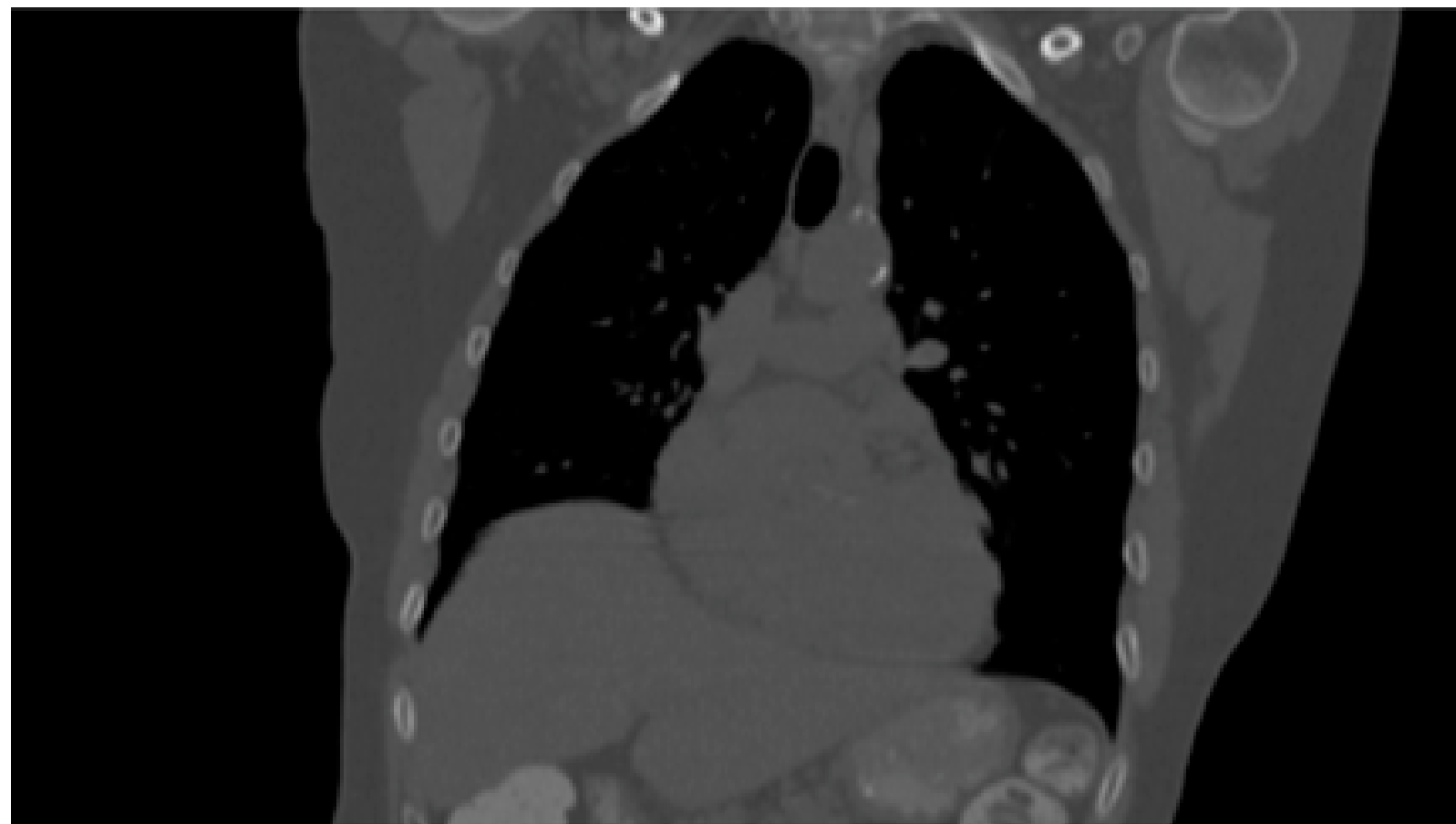
- Information about a patient is often obtained via several imaging techniques
- Different techniques reveal different features
- Some techniques are useful for pre-operative imaging, others can be used during surgery
- Challenge: To combine different imaging techniques
- Example: Removal of tumour from a liver with Minimally Invasive Surgery (MIS)

Medical imaging techniques

- Magnetic Resonance (MR) – 3D
- Computed Tomography (CT) – 3D
- Positron Emission Techniques (PET) – 3D
- Ultrasound – 2D and 3D
- X-ray – 2D
- Photo and video – 2D
- Etc.

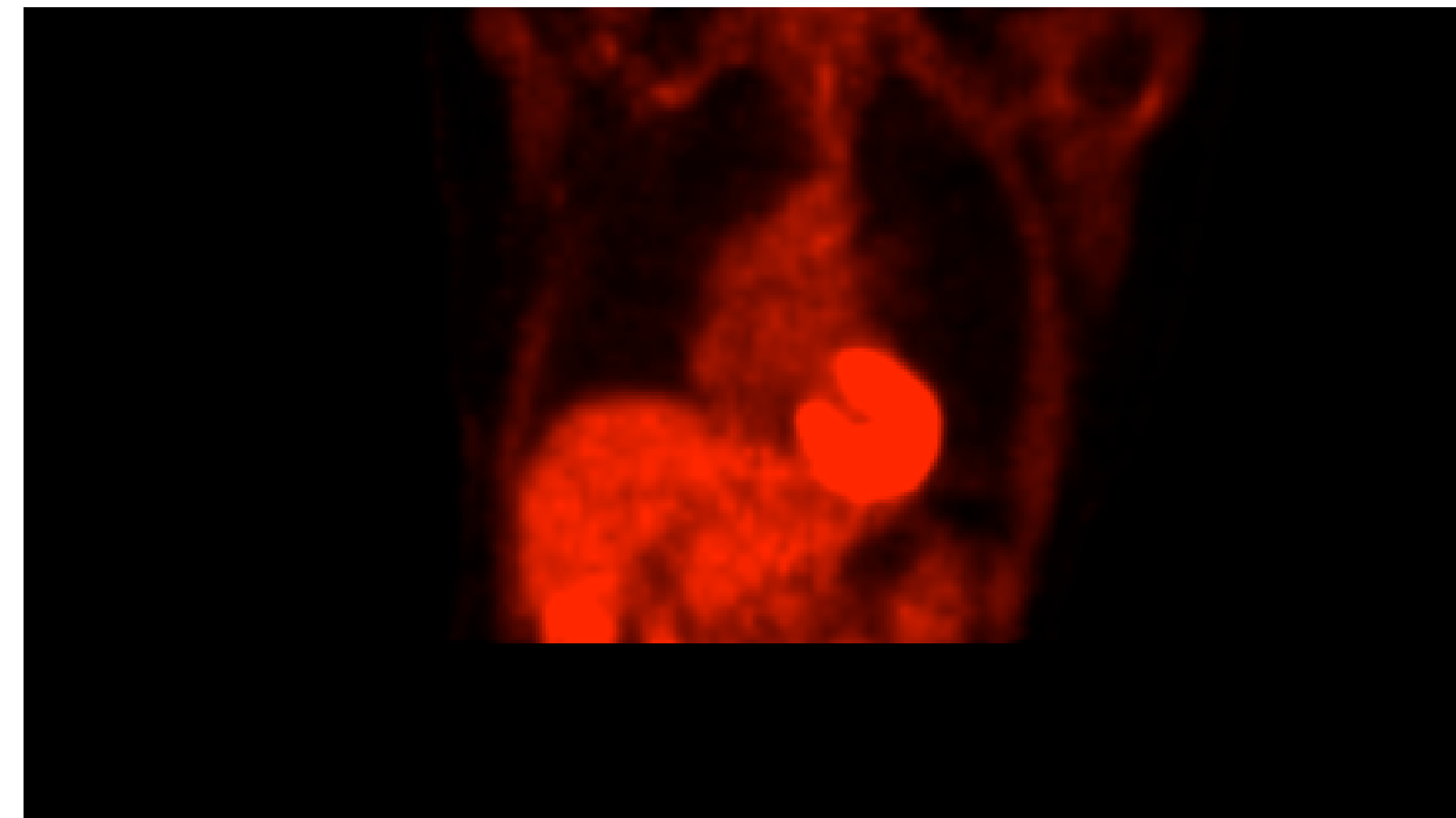
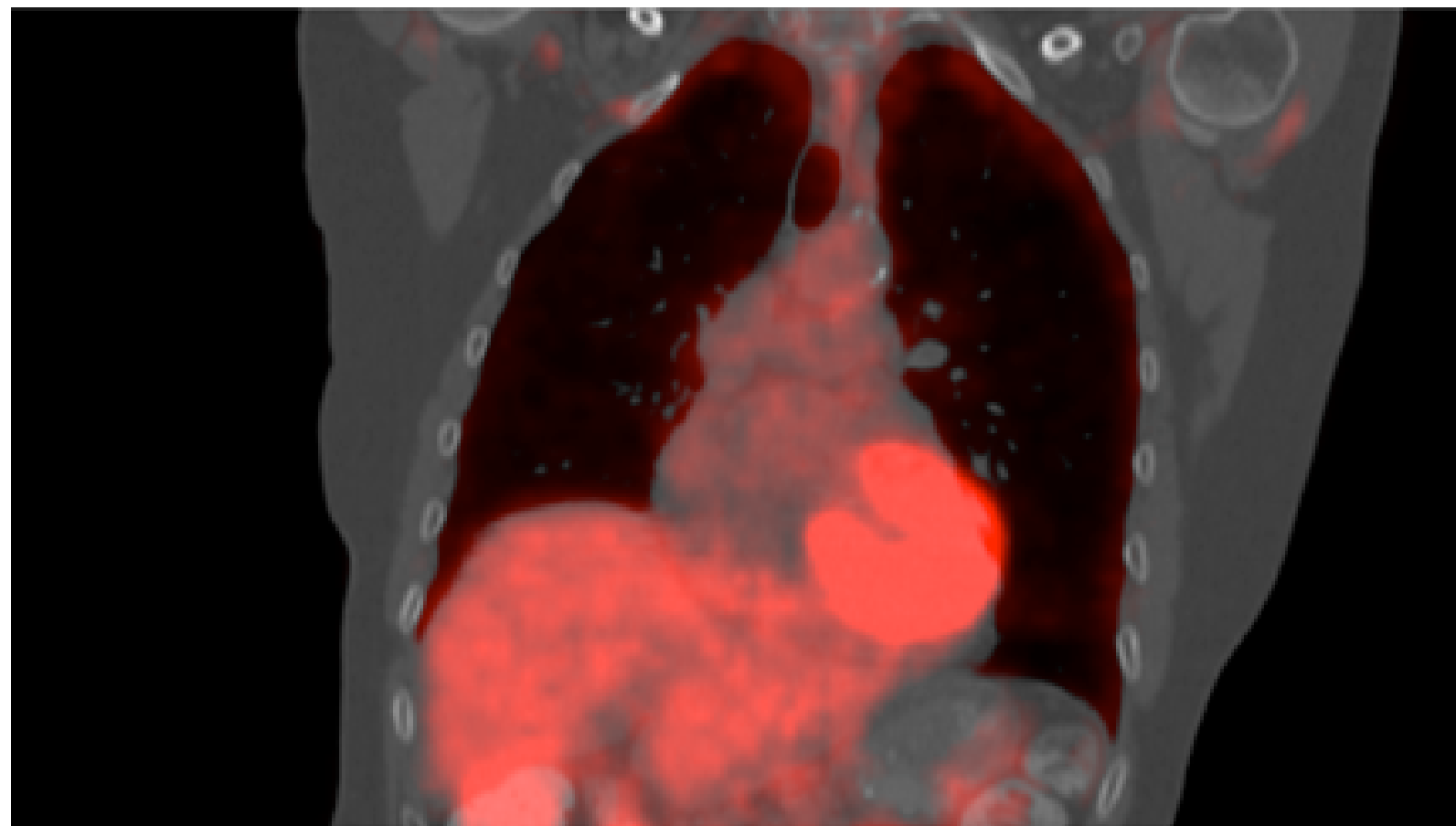
Research topic

Registration (alignment) of medical images (of the same objects) from different sources



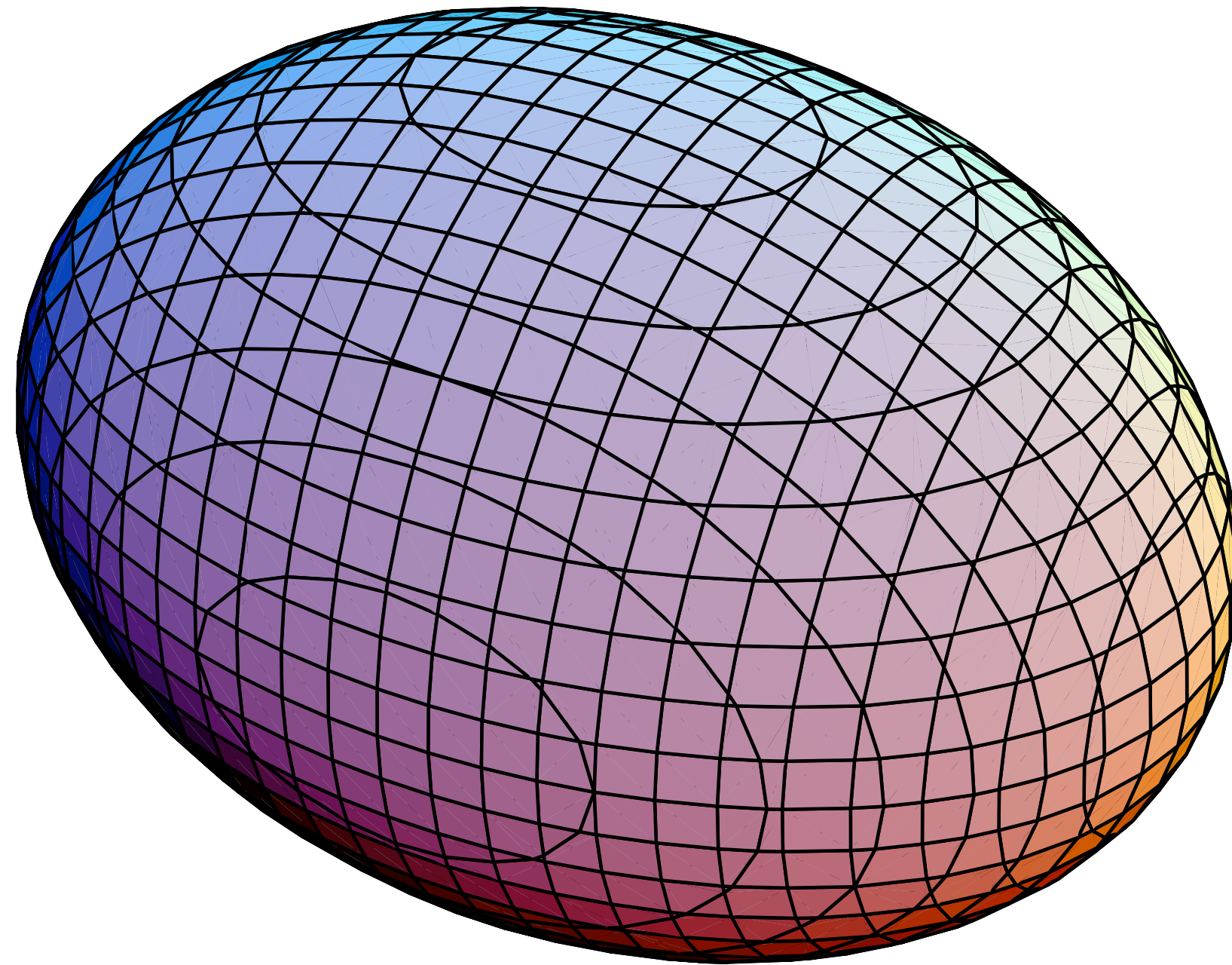
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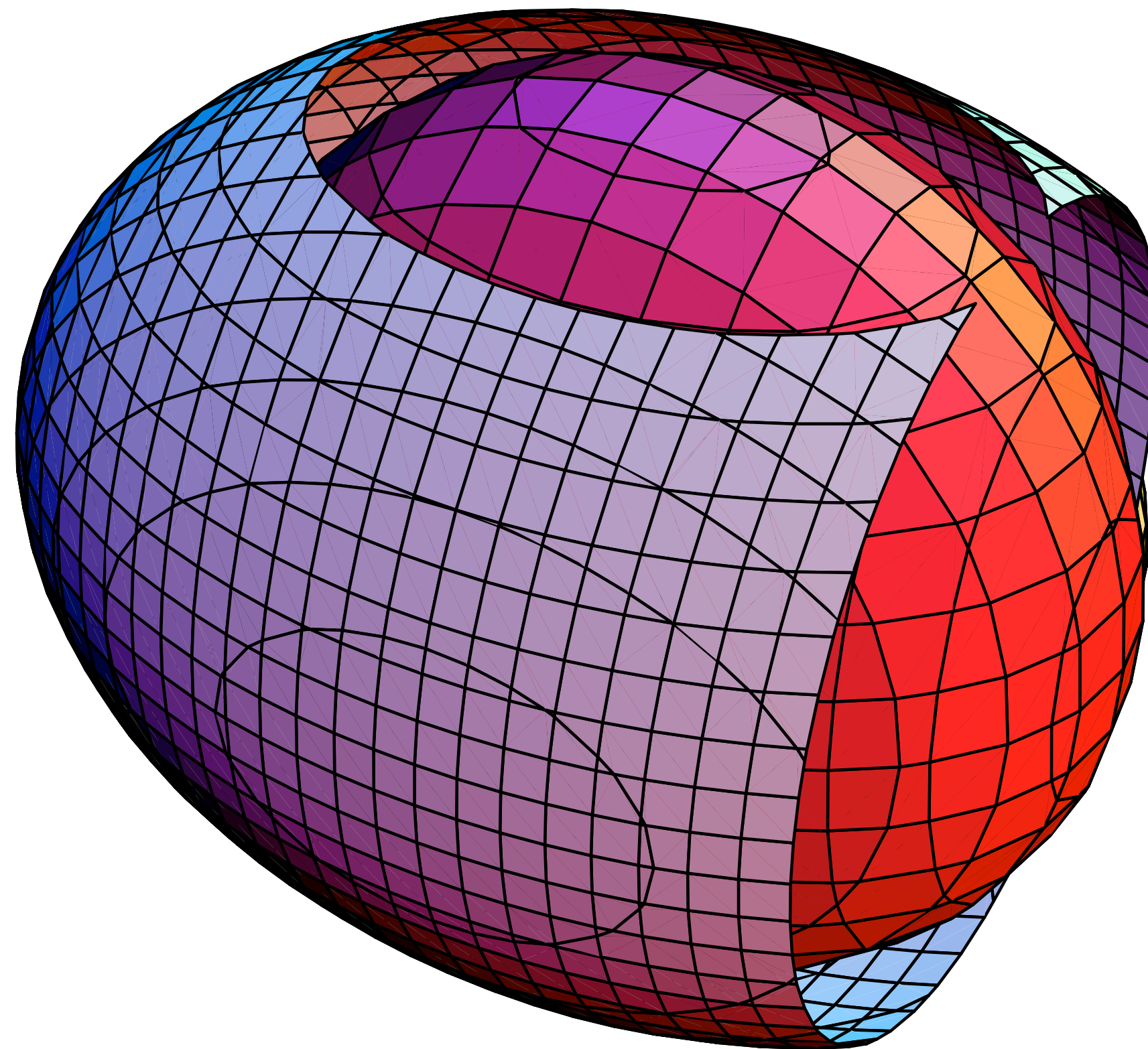


What is registration?

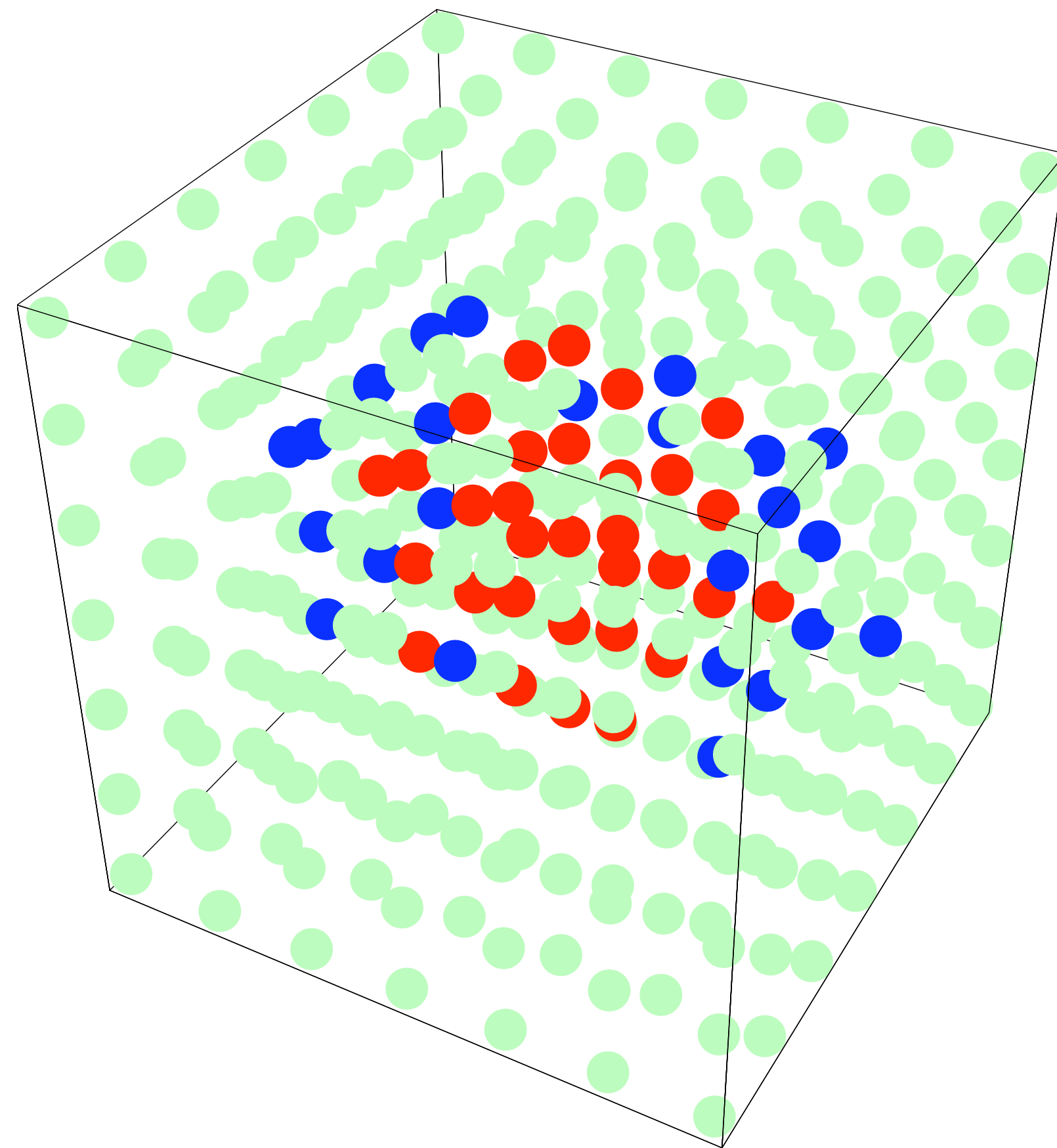
What is registration?



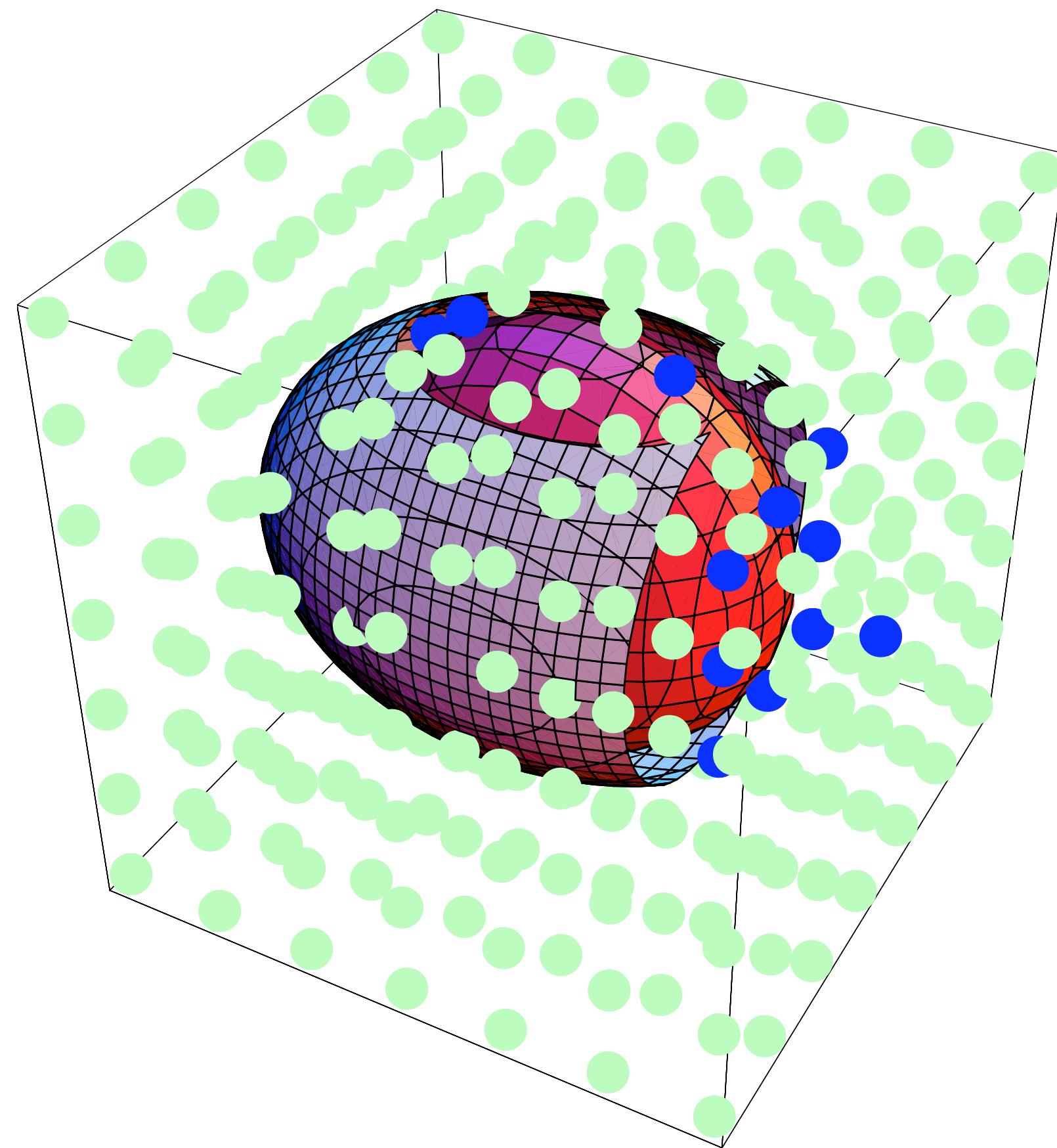
What is registration?



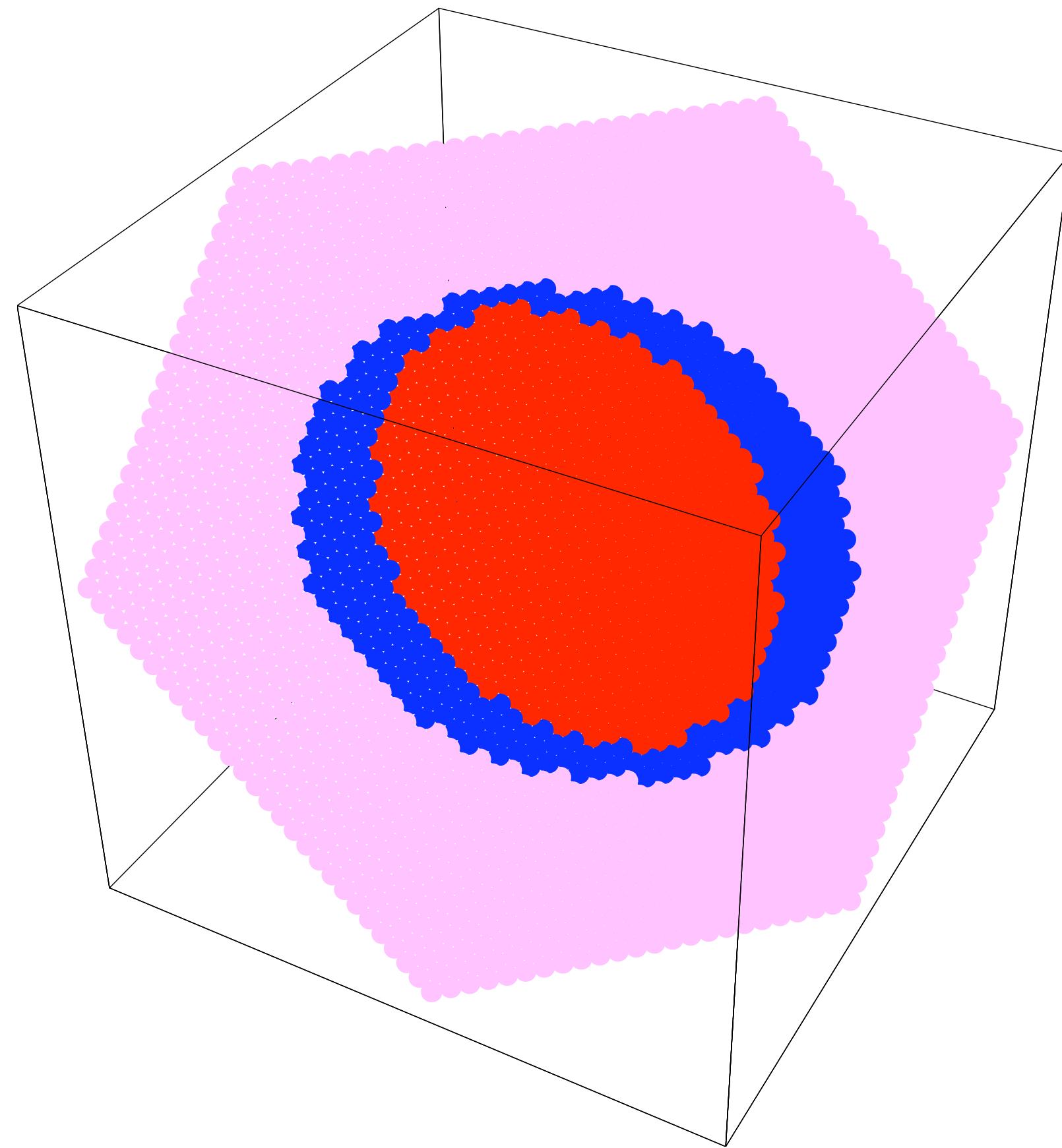
MR-scan



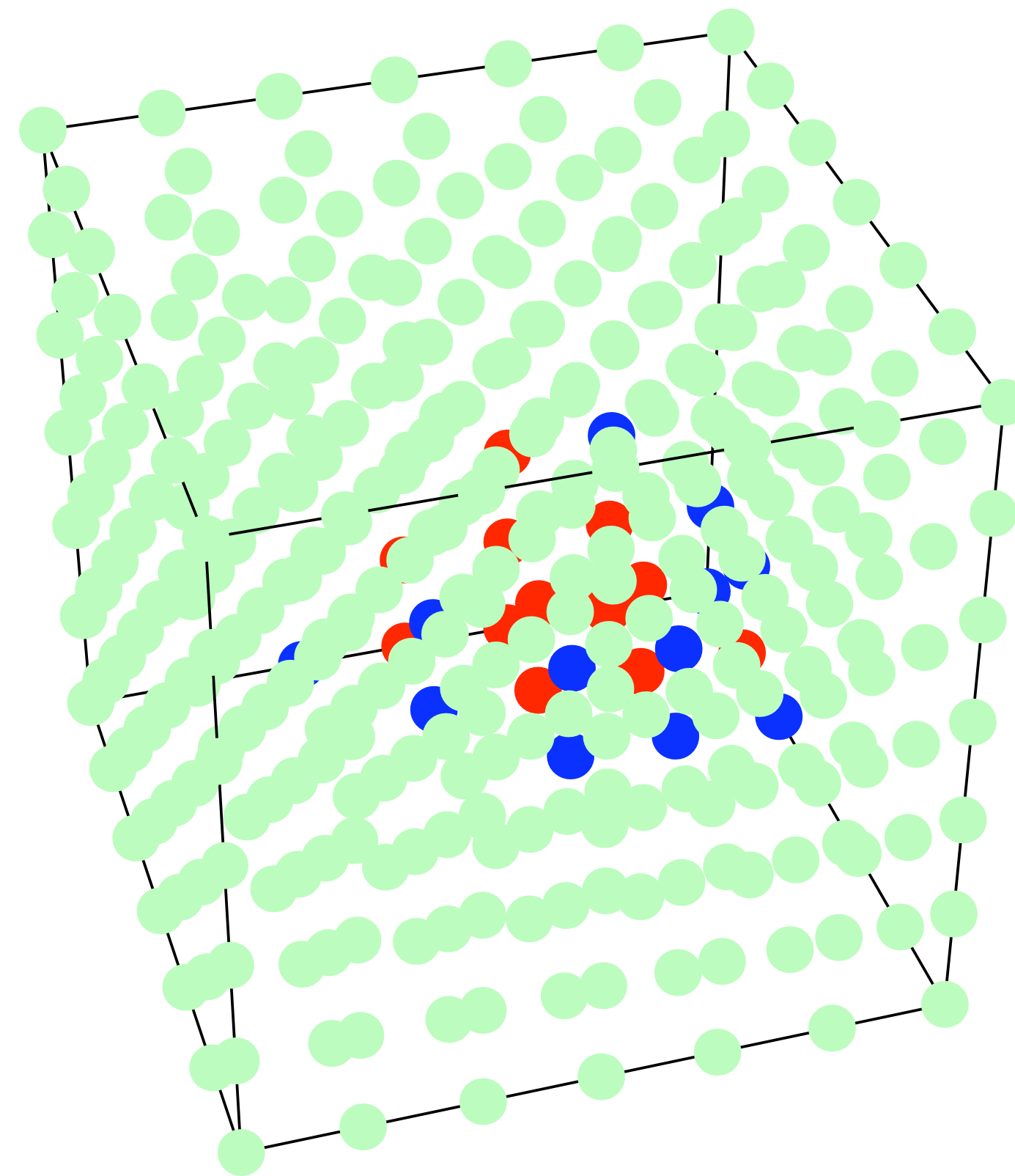
MR-scan



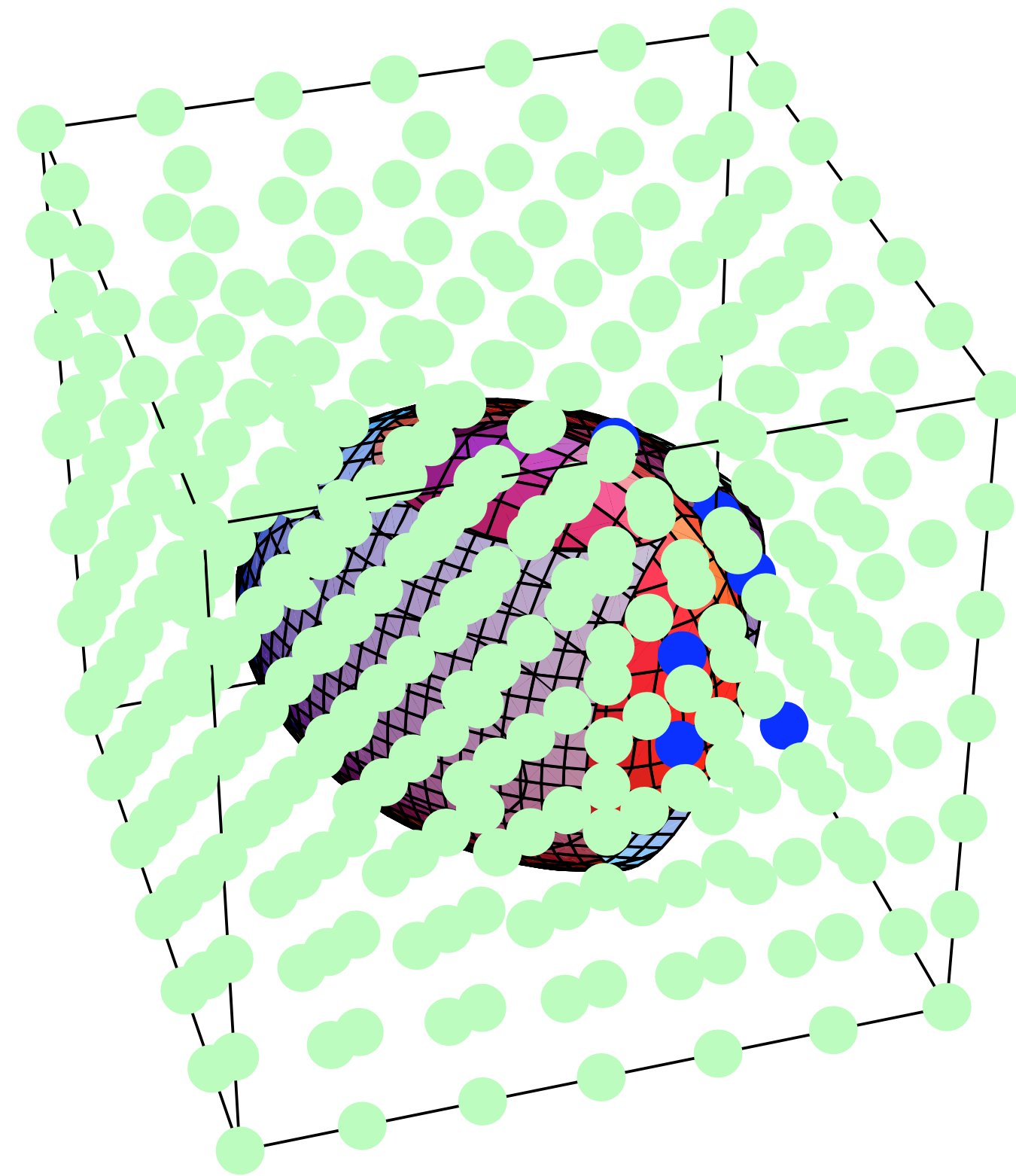
MR-scan, sliced



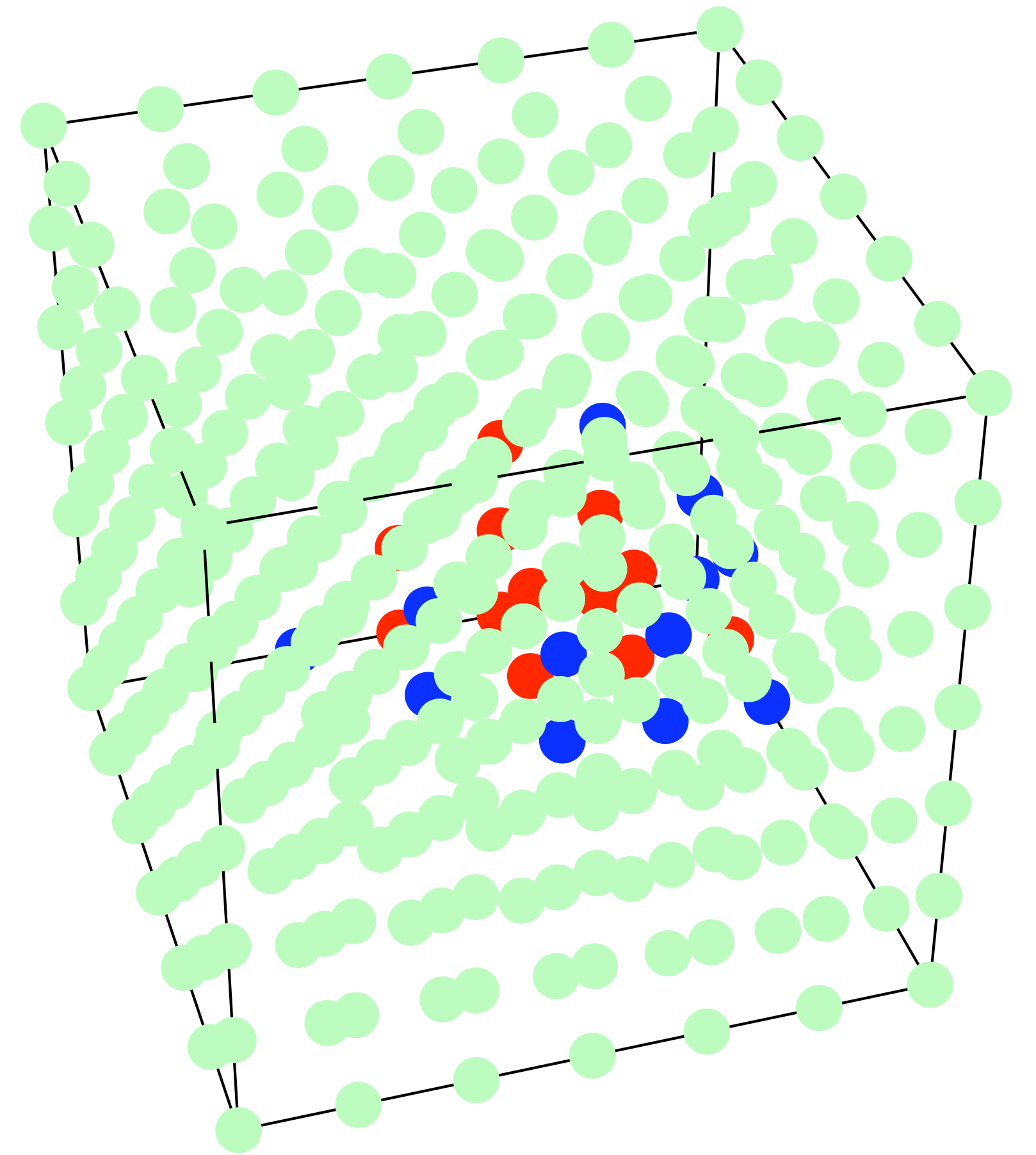
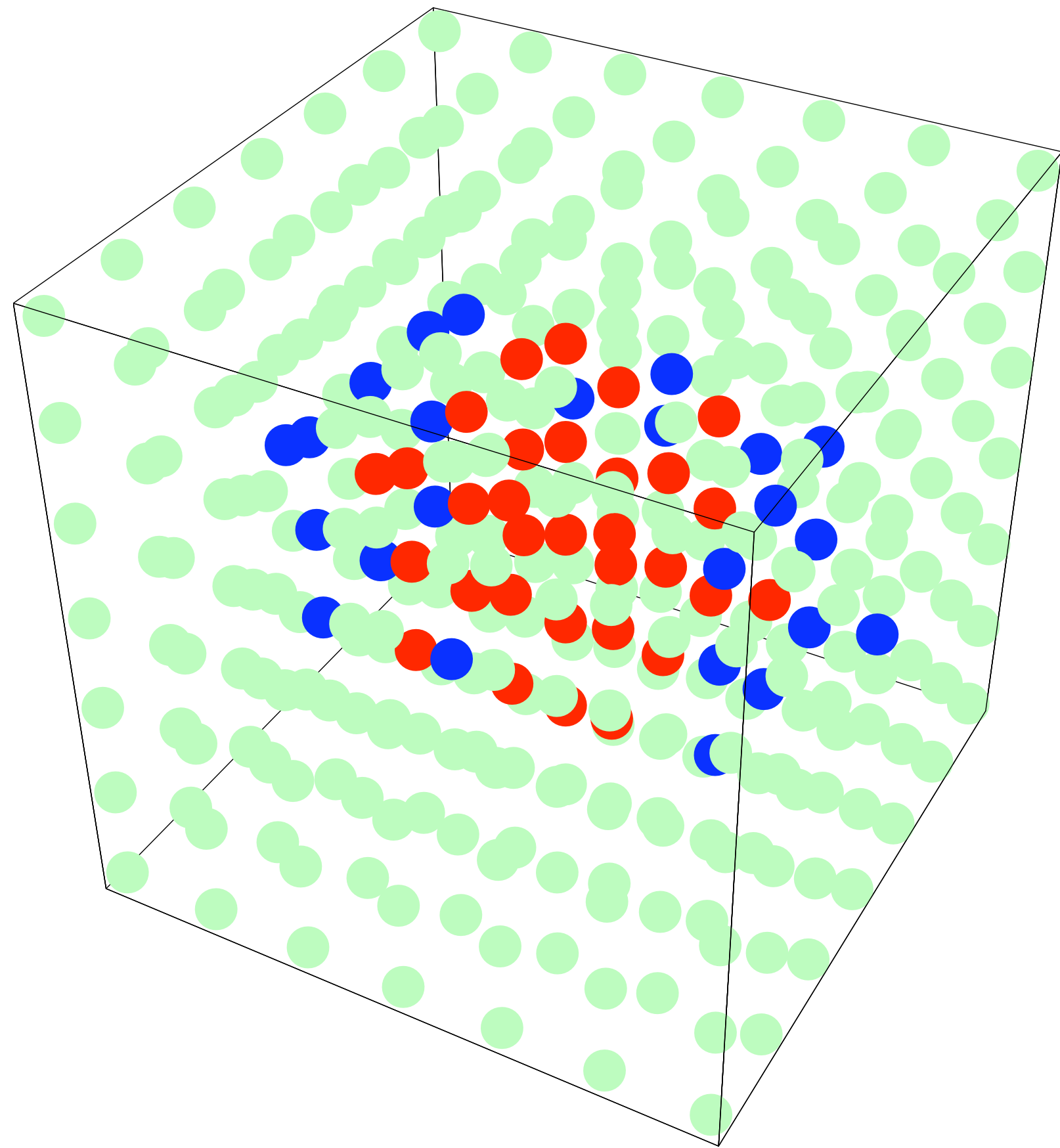
CT-scan



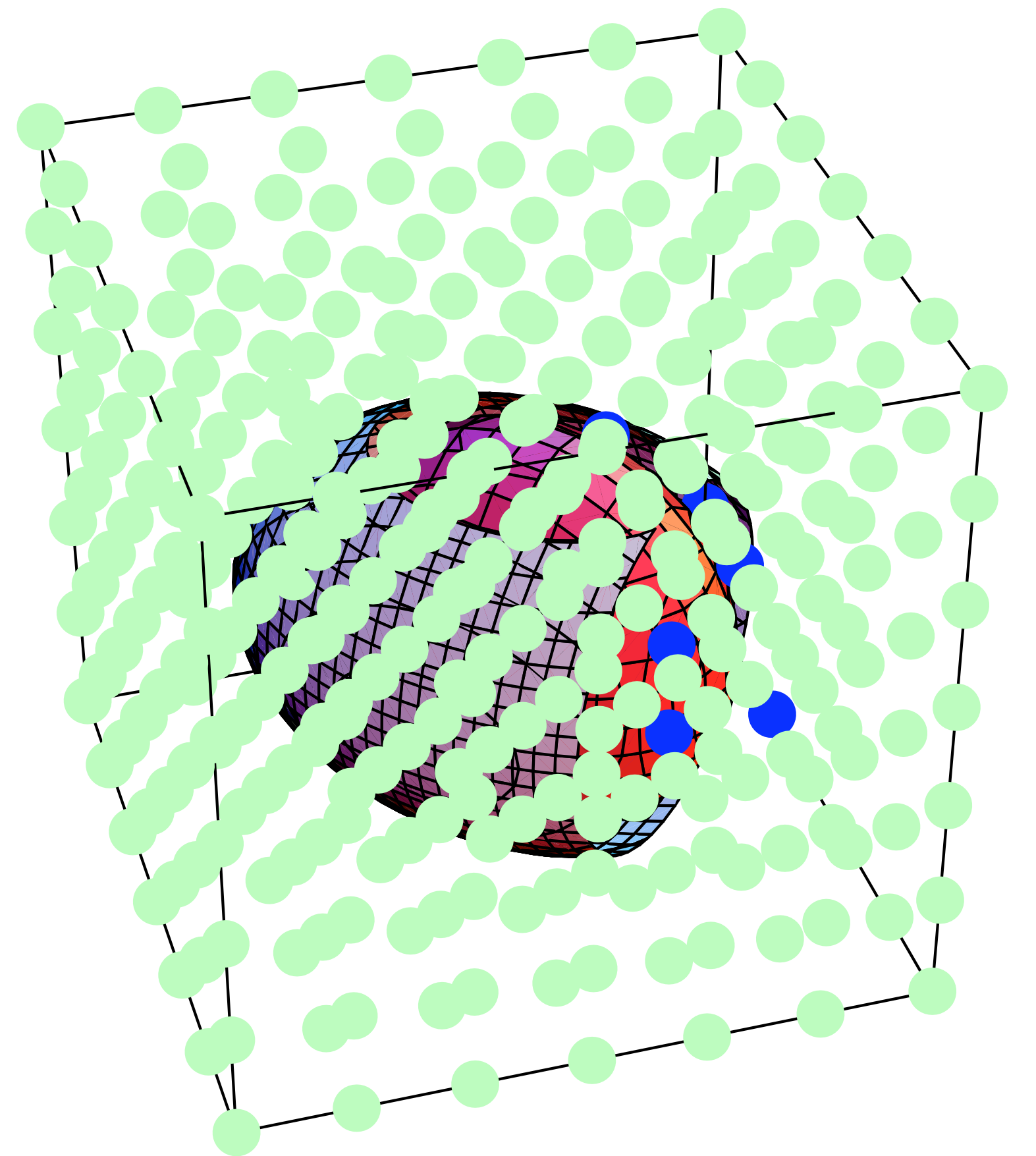
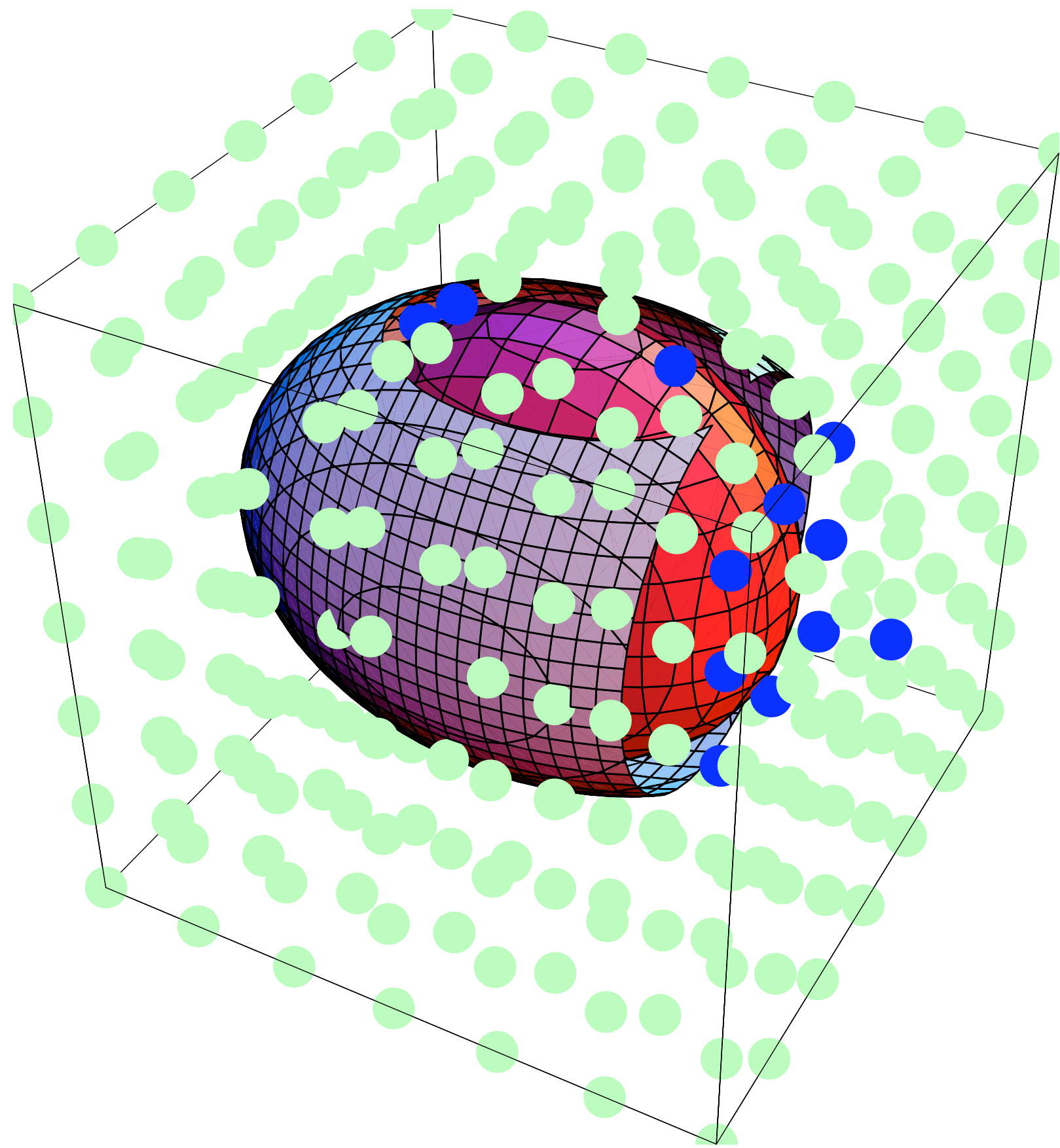
CT-scan



MR + CT

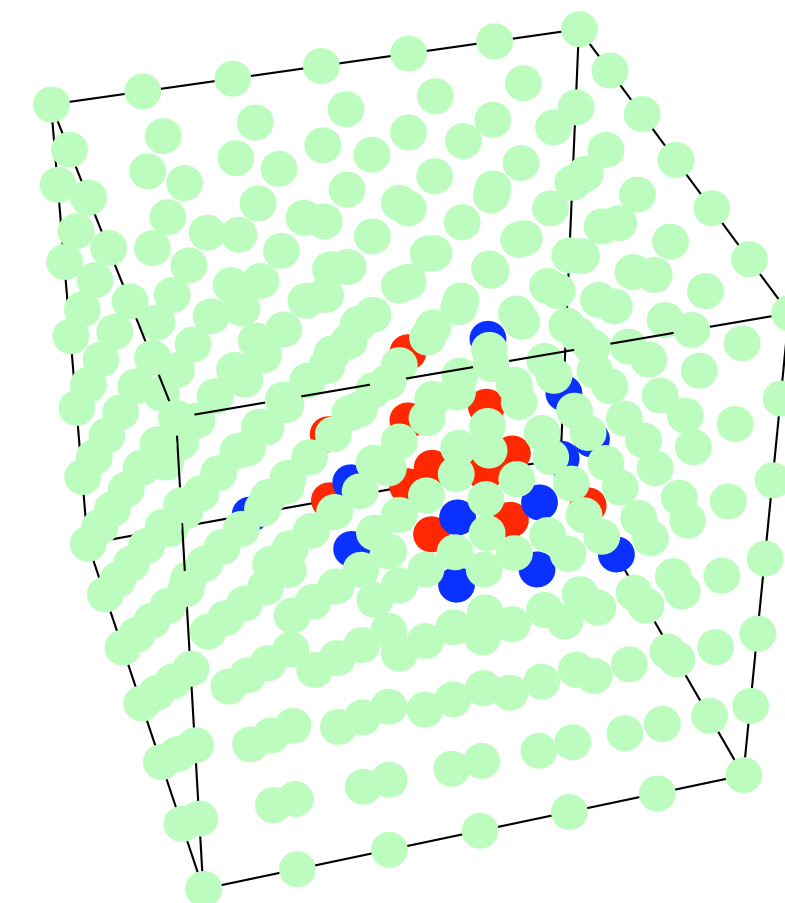
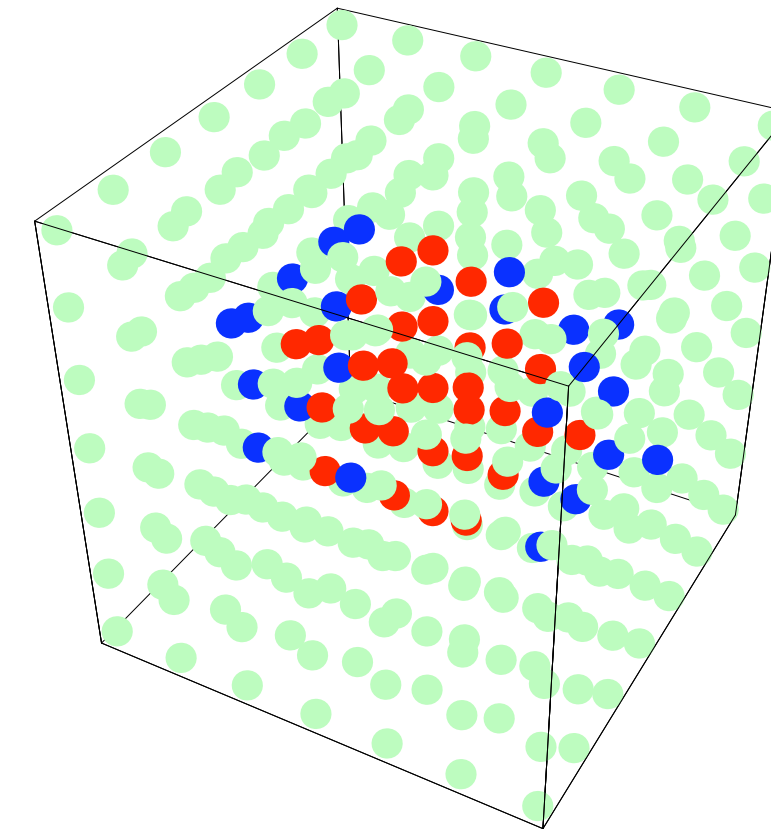


MR + CT



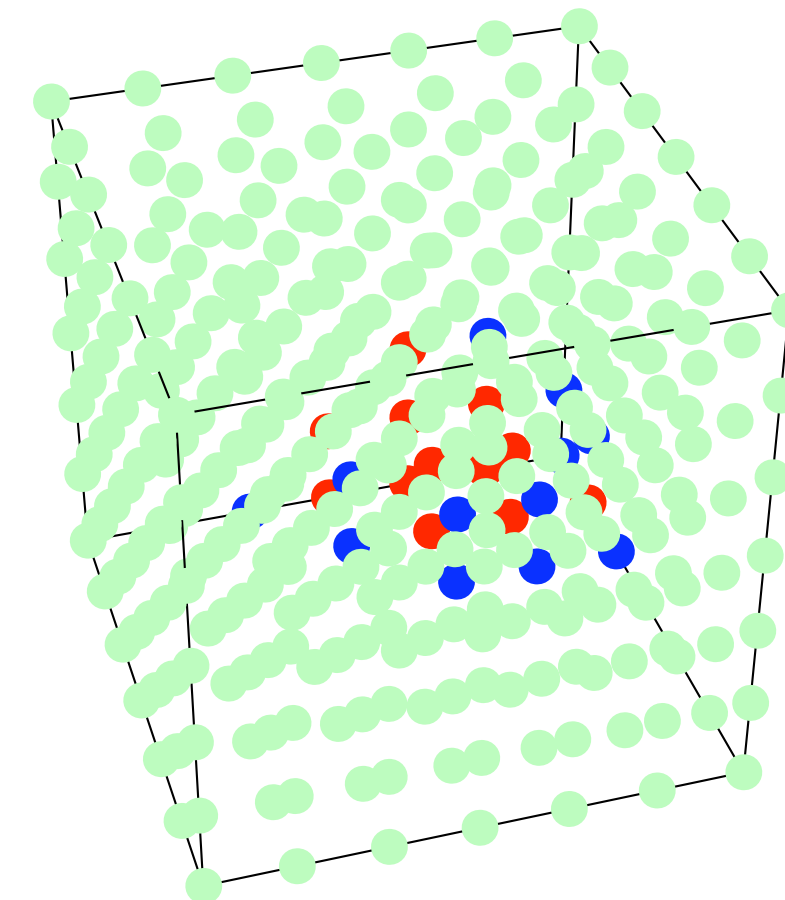
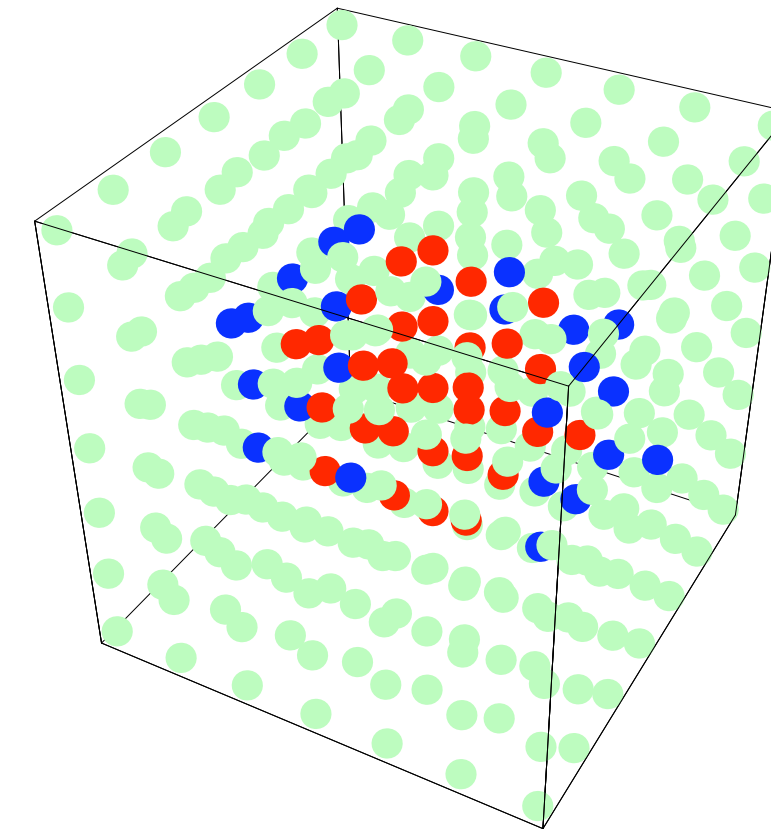
Registering MR and CT

- Registration: find a mapping that aligns the two data sets in the same coordinate system

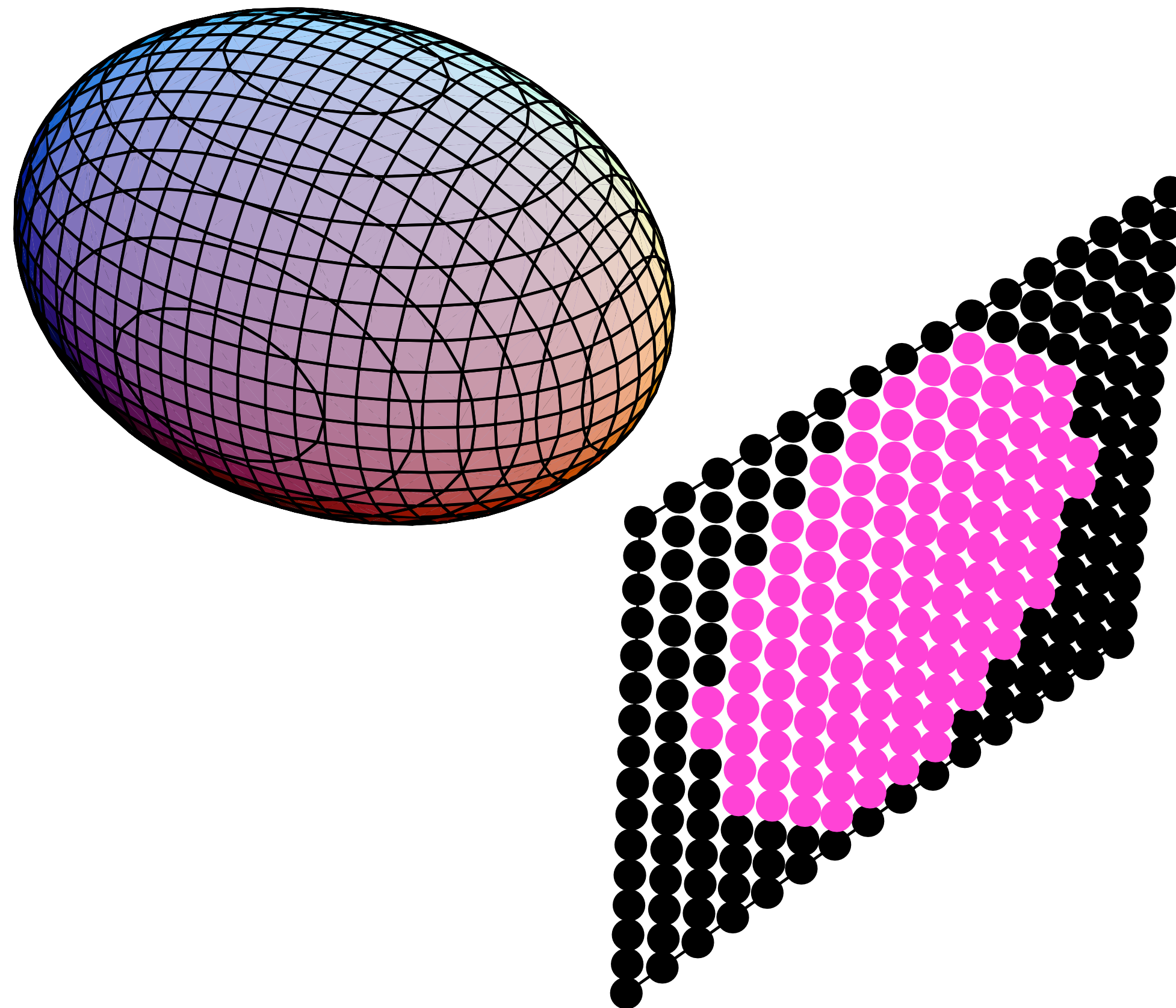


Registering MR and CT

- Registration: find a mapping that aligns the two data sets in the same coordinate system
- Challenges
 - MR measures concentration of hydrogen
 - CT measures ability to absorb x-rays
 - Scans may be taken at different times - deformation possible



Photo



X-ray

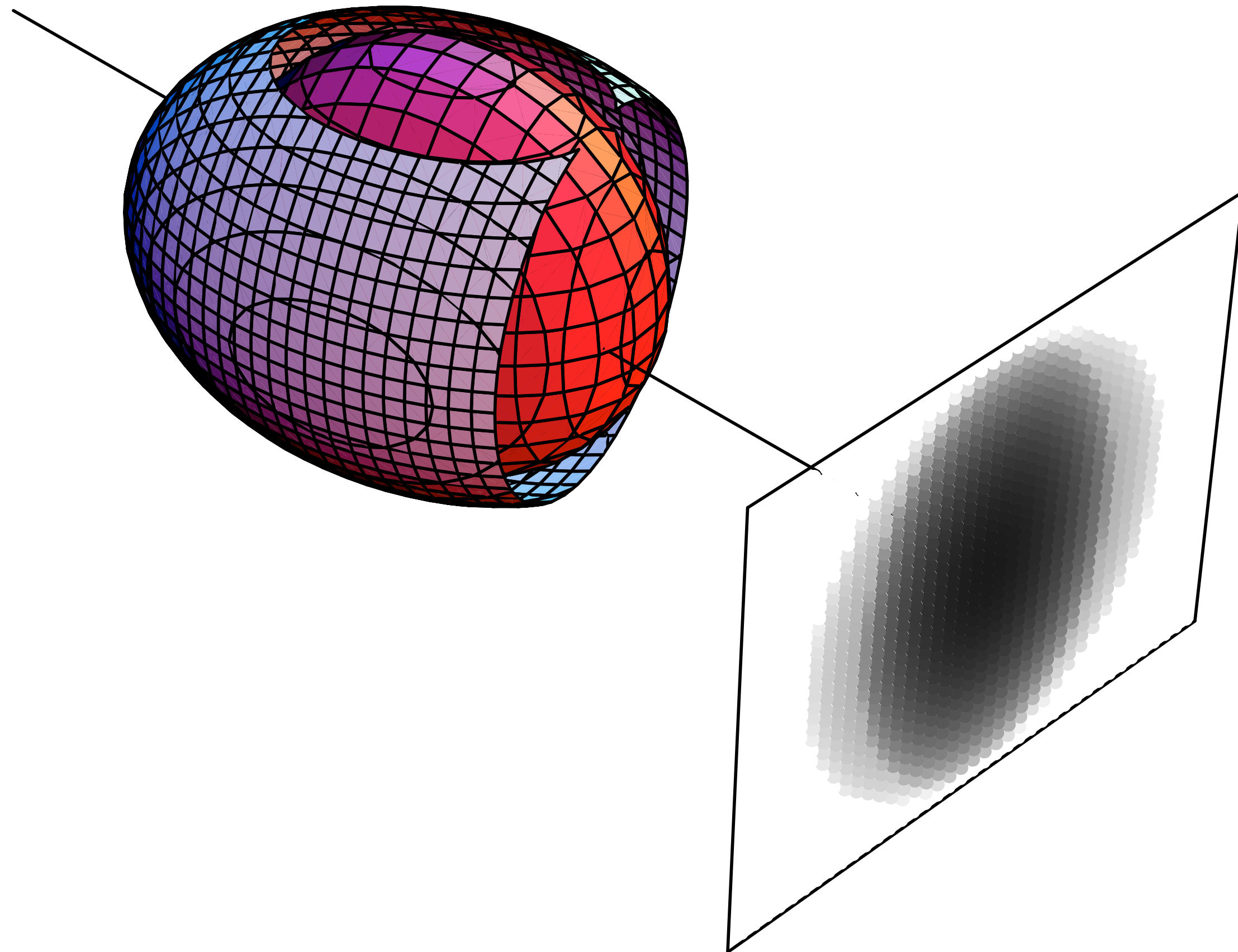
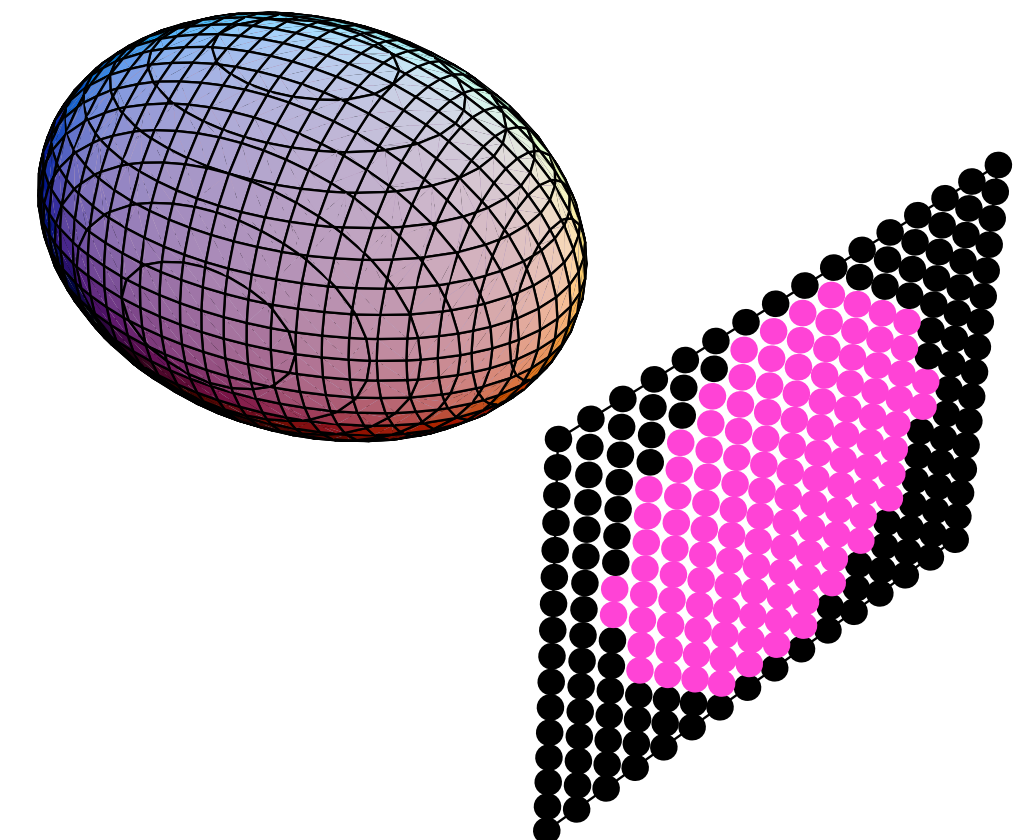
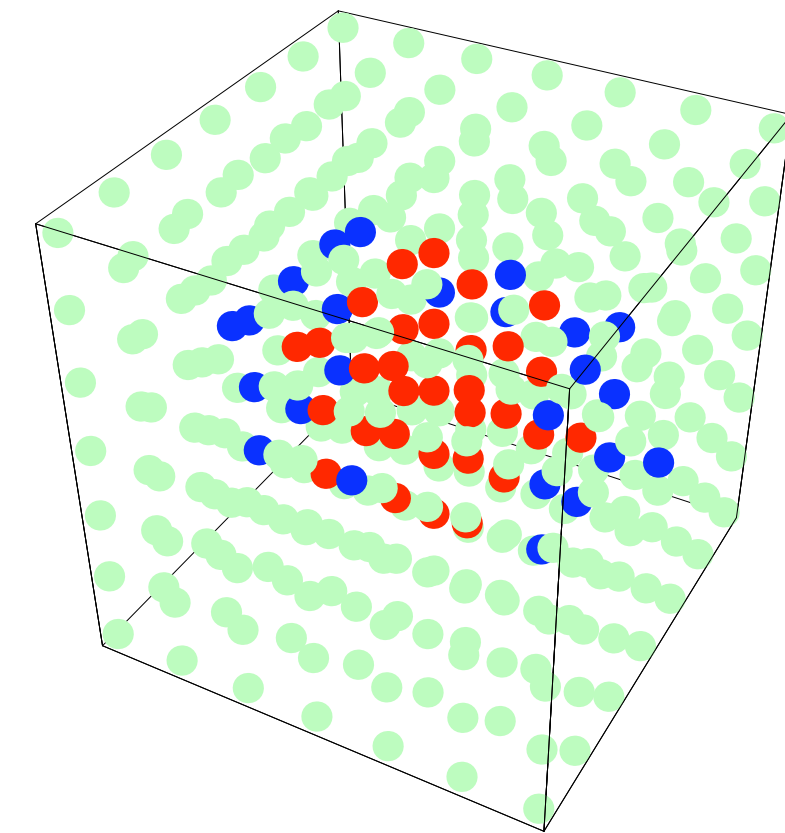


Photo (video) and MR

- Challenges for registration
 - May need to compensate for optical deformation caused by camera
 - Scan and photo recorded at different times - deformation



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Typical registration procedure

- Find information that is common in the two images
- Choose a space of transformations (rigid, affine etc.)
- Choose a similarity measure
- Determine the transformation from one image to the other by minimizing the similarity measure
- Many variations

Research in this project

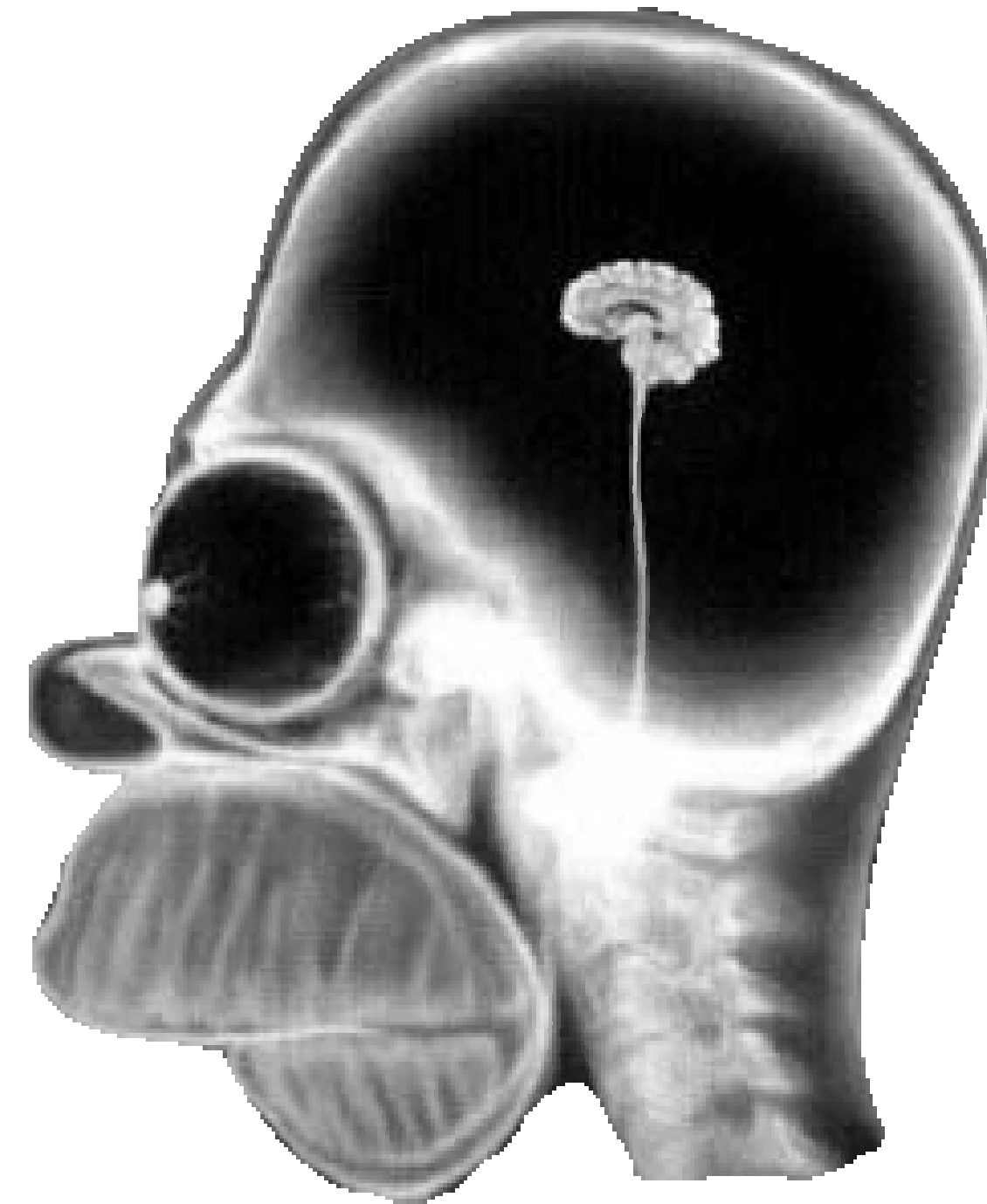
- Non-rigid registration
 - When images recorded before, during and after surgery are to be registered, non-rigid transformations are necessary
 - Certain pde-based methods are promising
 - CPU-intensive

Research in this project

- Registration of MR and video stream, e.g., removal of tumour from the liver
 - MR taken before surgery, video during surgery
 - The liver will have moved and changed shape
 - Need close to real-time registration



Homer Simpson
(labelled atlas)



Homer Simpson
(MRI)