# ex5-coordinate-systems

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## 1 Example 5: Coordinate systems

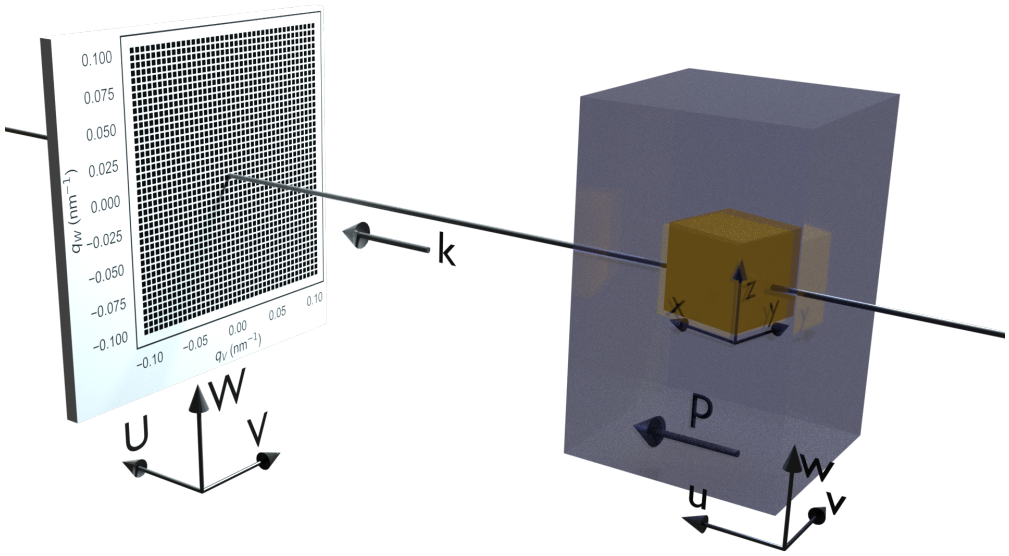


Image showing relative orientation of three coordinate systems

### 1.1 Overview of three coordinate systems

To describe a general SANS experiment, one needs to consider *three* coordinate systems, as shown in the figure above. These coordinate systems are:

- The *beamline coordinates*, denoted with capital letters $U$, $V$, $W$. The (longitudinal) direction $U$ is parallel to the neutron beam ($\vec{k}$) passing through the sample. The detector plane is aligned with the transverse directions $V$ (horizontal) and $W$ (vertical).
- The sample is placed in a sample environment (e.g. a cryostat), which defines the *sample environment coordinates*, which are denoted with lower-case letters $u$, $v$, $w$. Within the code it is implicily assumed that the neutron polarisation is defined by a field set in the sample environment.
- The *sample coordinates* $x$, $y$, $z$ are used to specify positions $\vec{R}_i$ and moments $\vec{M}_i$ of the individual scatterers, e.g. which are the result of micromagnetic simulations.

If no relative rotations between the (right-handed) coordiante systems are considered, the relative alignment of the principal axes is as follows:

- $U \parallel u \parallel x$, parallel to beam direction
- $V \parallel v \parallel y$, horizontal direction in detector plane
- $W \parallel w \parallel z$, vertical direction in detector plane

Ideally, the micromagnetic simulations are done in a geometry that is largely aligned with the scattering geometry under investigation. For this it might be neccessary to swap axes, e.g. for a thin film, typically one chooses a $z'$ coordinate to be paralel to the surface normal, which would need to be swapped to the $x$ coordinate to be parallel to the beam direction.

### 1.2 Specifying rotations

Rotations of the sample and the sample environment can be defined with the `mm2SANS.Probe.sample_rotations` and `mm2SANS.Probe.sample_environment_rotations`, respectively. The rotations are specified as a list of rotations around the principal axes of the sample, respectively the sample environment, which initially is collinear with the beamline coordinate system.

Rotations are specified as a combination `[rotation_type, rotation_angle]`, where the first is a string which can be `"roll"`, `"pitch"` or `"yaw"`, and the latter is the rotation angle $\phi$ in degrees. The types encode the following rotations:

- `roll`: Rotation around axis parallel to the neutron beam $x$, respectively $u$. Positive angles $\phi$ correspond to counter-clockwise rotations when viewed in the beam direction.
- `pitch`: Rotation around the horizontal axis $y$, respectively $v$. Positive angles $\phi$ tilt the sample/cryostat towards the detector.
- `yaw`: Rotation around the vertical axis $z$, respectively $w$. Positive angles $\phi$ rotate the sample/crostate to the positive $U$ direction.

### 1.3 Neutron polarisation

It is implicitly assumed that the neutron polarisation $\vec{P}$ is defined by the magnetic field at the sample position within the sample environment. When an `mm2SANS.Experiment` object is initiated, thus the vector $\vec{P}$ is transformed according to the rotations specified in `probe.Beamline.sample_environment_rotations`. If the neutron polarisation is set in the beamline coordinate system $U$, $V$, $W$, its value stored in the field `Experiment.Probe.Beamline.neutron_polarisation` needs to be reset explicitly.