Flapping wings display complex flows which can be used to generate large lift forces. Flexibility in wings is widely used by natural flyers to increase the aerodynamic performance. The influence of wing flexibility on the flow can be computed using numerical analysis with Fluid Structure Interaction (FSI). However, there is a lack of open-source FSI methods. Therefore, a new implementation is developed for the well-known CFD code OpenFOAM to facilitate FSI with the multi-physics coupling library preCICE. The OpenFOAM adapter does not require changes to the OpenFOAM source code and is compatible with a variety of OpenFOAM versions. Structural modelling is performed using the open-source code CalculiX.

The method is validated using the laminar incompressible cylinder-with-a-flap benchmark for one steady and two unsteady cases. Good coherence is seen for the deflection and force generation, but the coupled method is sensitive to the eigenmodes of the structural model.

The influence of inertial, elastic and aerodynamic forces is quantified using a 2D wing. A sinusoidal flapping motion is imposed on the leading edge of the vertical wing. The inertial force on the wing dominates for high mass ratios and the wing deflection is rather independent of the flow. For a low mass ratio, the wing deformation scales with the increasing elasticity. The maximum lift and lowest drag were found for the wing with large flexibility and low mass so the passive deformation by aerodynamic forces creates a favourable shape for lift production.

Flexible translating and revolving wings at an angle of attack of 45 degrees show that chordwise flexibility decreases both lift and drag, however the lift over drag ratio is increased. The flow around both wings forms a coherent structure with a Root Vortex (RV), Tip Vortex (TV), Leading Edge Vortex (LEV) and Trailing Edge Vortex (TEV). The LEV on the revolving wing is stable for approximately up to half the span because vorticity is transported outward in the vortex core. The flowfield and LEV breakdown are consistent with experimental data of the same wing. The translating wing builds up circulation but the LEV detaches quickly near the centre of the wing. Chordwise bending reduces the angle of attack which decreases the distance to the core of the shed LEVs.