补充材料中的公式：



, *阻力系数*

*Cij 邻接矩阵*

*X 代表位置*

*时间*

*an attractive flow*

*、 第i个、第j个细胞的角速度*

*对等号右侧公式的整体解释*

2.

第i个鞭毛所施加的力矩

、 都是阻力系数，和上一个式子的一个意思 维度： μa2

等式左侧第一项：相对于静止腔壁的旋转而产生的阻力

等式左侧第二项：在临近细胞旁旋转产生的阻力

进行无量纲化







等式的右侧代表：第i个细胞的力矩相对于平均力矩 的无量纲化值。

目前的版本用的公式：  
Pairwise interaction:

where and are the position vectors of micro-disks;

is the vector pointing from the centre of micro-disk *j* to the centre of micro-disk *i*;

and are the orientations of micro-disks;

*d* is the edge-edge distance;

is the angle of dipole moment with respect to . It is assumed to be the same for both micro-disks, as in scheme S1 in the section on magnetic dipole force and torque calculation.

is the instantaneous spin speed of micro-disks;

is the orientation of the magnetic field;

is the rotation speed of the magnetic field;

is the radius of micro-disk (150 µm);

is the dynamic viscosity of water (10-3 Pa·s);

is the density of water (103 kg/m3);

is the magnetic dipole moment of the micro-disks (10-8 A·m2);

is the magnetic field strength (10 mT);

*C* is an adjustable coefficient.

and are the magnetic dipole force on and off the centre-to-centre axis, respectively, and they are functions of and ; (See the section on magnetic dipole force and torque calculation for details)

is the magnetic dipole torque, and it is a function of and .