



ASPHERIX

PRODUCT  
INFORMATION



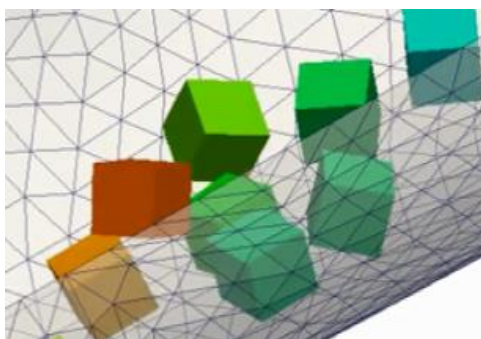
**DCS**  
COMPUTING



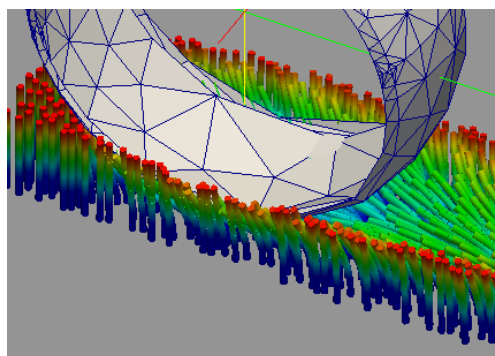
Aspherix® supports a large variety of particle shapes



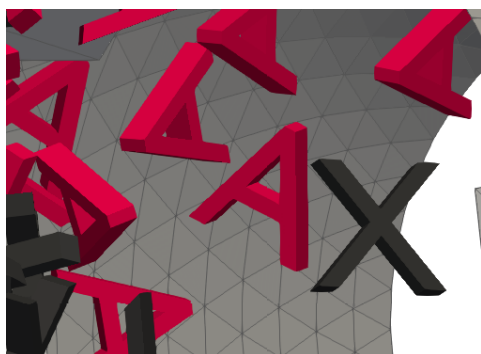
Convex triangulated



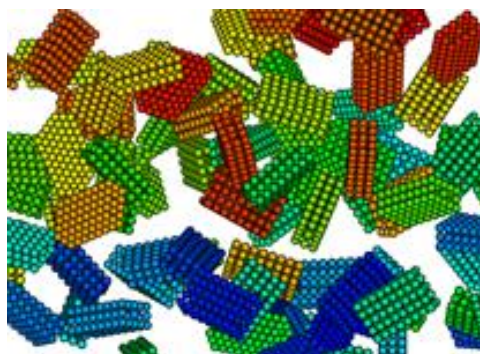
Fiber and bonded



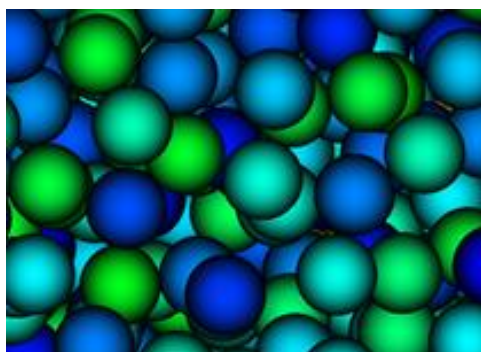
Concave triangulated



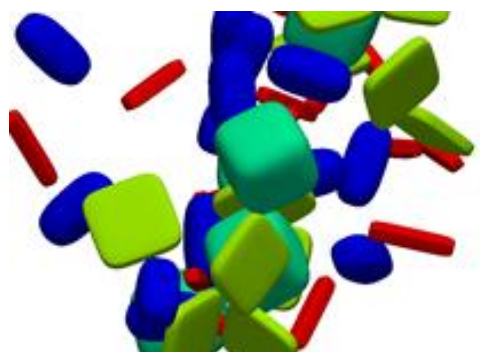
Multisphere



Sphere



Box, cylinder, ellipsoid

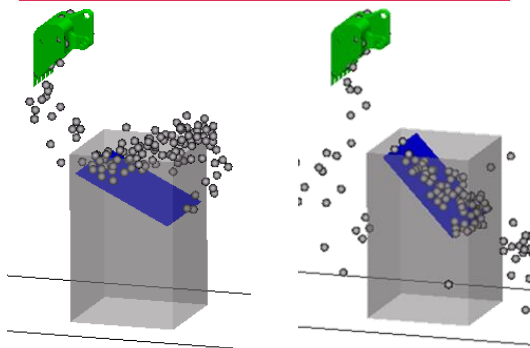


S: functionality available in Aspherix® Solver only.  
+: functionality not available in Aspherix® BASIC.

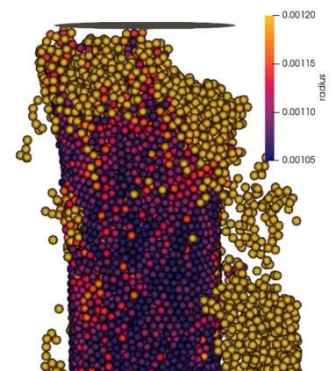


Aspherix® has numerous cutting-edge physics models and great options for integration. Here are some highlights:

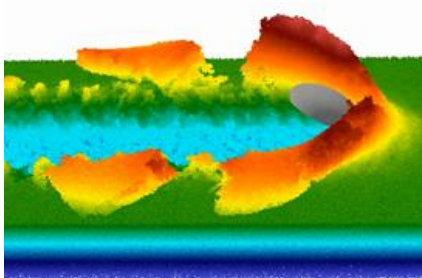
### 6 degree of freedom solver



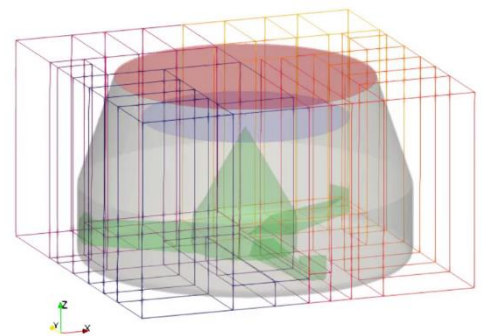
### Powder compaction



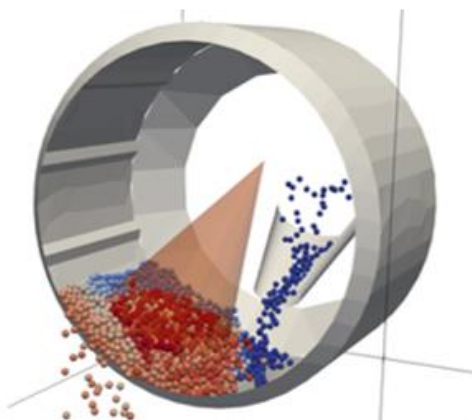
### Cohesion models



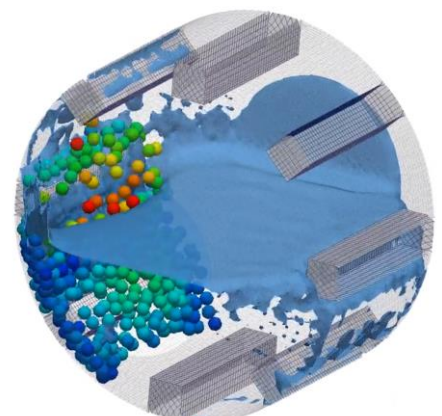
### Loadbalancing



### Spray coating



### Coupling interface



S: functionality available in Aspherix® Solver only.  
+: functionality not available in Aspherix® BASIC.

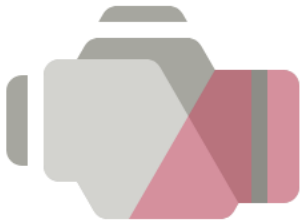


## COMPONENTS AND OPTIONS

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Aspherix® consists of the following components:

Strong simulation engine for DEM



Easy to use GUI for DEM



GUI workflow for coupled CFD-DEM simulations



Aspherix® runs on:

Desktop machines



Clusters



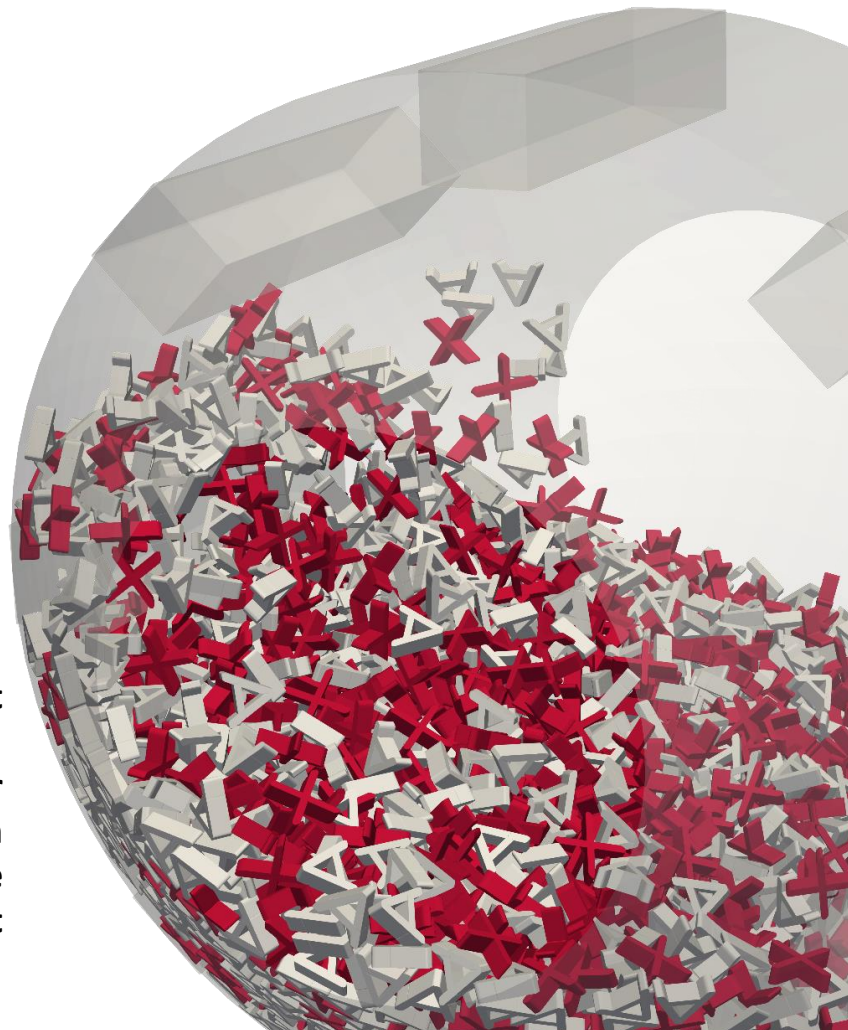
Clouds



**ASPHERIX® is available for Linux and Windows**

# FEATURE LIST OVERVIEW

The feature list overview is a list of all Aspherix® functionalities. Restrictions (Aspherix® Solver only functionalities, information about Aspherix® Basic) can be found in the detailed feature list starting from page 13.





### Physics models

- |                                       |  |
|---------------------------------------|--|
| • 6 degrees of freedom solver         | • magnetic dipole                      |
| • body forces                         | • mass transfer and chemical reactions |
| • bond models                         | • material property models             |
| • cohesion                            | • mesh deformation                     |
| • damping                             | • normal models                        |
| • drag forces                         | • pair styles                          |
| • electricity                         | • particle breakage and attrition      |
| • equipment wear and attrition        | • particle deformation                 |
| • fast DEM                            | • powder compaction                    |
| • fiber cutting                       | • rolling friction                     |
| • fiber models                        | • sedimentation                        |
| • heat transfer                       | • spray coating                        |
| • liquid bridges and liquid transport | • tangential models                    |



### Particle shapes

- |                        |                |
|------------------------|----------------|
| • bonded               | • fiber        |
| • box                  | • general      |
| • capsule              | • multisphere  |
| • concave triangulated | • rod          |
| • convex triangulated  | • sphere       |
| • cylinder             | • superquadric |
| • ellipsoid            | • tablet       |



### Meshes and geometry

- |                     |                |
|---------------------|----------------|
| • mesh              | • mesh modules |
| • mesh controllers  | • region       |
| • mesh import       | • walls        |
| • mesh manipulation |                |



### Functionalities

- |                       |                         |
|-----------------------|-------------------------|
| • boundary conditions | • particle deletion     |
| • integration         | • particle insertion    |
| • neighbor list       | • particle manipulation |



### Postprocessing



- collision statistics
- energy balance
- fiber data
- intra-particle coating variability
- mesh residence time
- meshes
- other
- particle data
- residence time distribution
- spatial and temporal averaging
- stresses and force network

### IO



- meshes
- reader
- write expert
- write standard

### Scalability and speed



- coarsegraining
- loadbalancing
- parallelization





### Coupling interface

- CFD 1-way coupling
- CFD 4-way coupling (Linux only)
- FEM coupling
- FEM coupling (Linux only)
- MBD coupling



### API

- API: C++
- API: Python
- custom contact models
- custom equations
- custom mesh access
- custom particle properties



## SYSTEM REQUIREMENTS

### Aspherix® Solver - MPI

#### Windows

- delivered with installer

#### Linux

- MPI is required
- has to support MPI 3 standard, OpenMPI 1.8 or newer or MPICH 3.0 or newer are required

### Aspherix® Solver - API

#### Linux

- cmake is required (min cmake 3.9)

### System requirements - Operating systems

- Windows 10
- Ubuntu 18.04, 20.04, 22.04
- Centos 7, Stream 9
- Red Hat 7, 9
- Suse Enterprise 12,15; Open Suse tumbleweed
- GUI requires glibc 2.17 or higher

### Operating Systems – Special cases

- Centos Stream 8 (Aspherix® Solver ONLY, no GUI support)
- Windows Server 2019, 2022 (Aspherix® GUI needs OpenGL 3.2)



## SYSTEM REQUIREMENTS

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### Prerequisites for coupling interfaces only

CFDEMcoupling:

- OpenFOAM 8\*
- Linux only (systems as specified on previous page)
- System prerequisites of specified OpenFOAM version apply

Palabos:

- Palabos 2.1
- Linux only (systems as specified on previous page)
- System prerequisites of specified Palabos version apply

### Additional remark

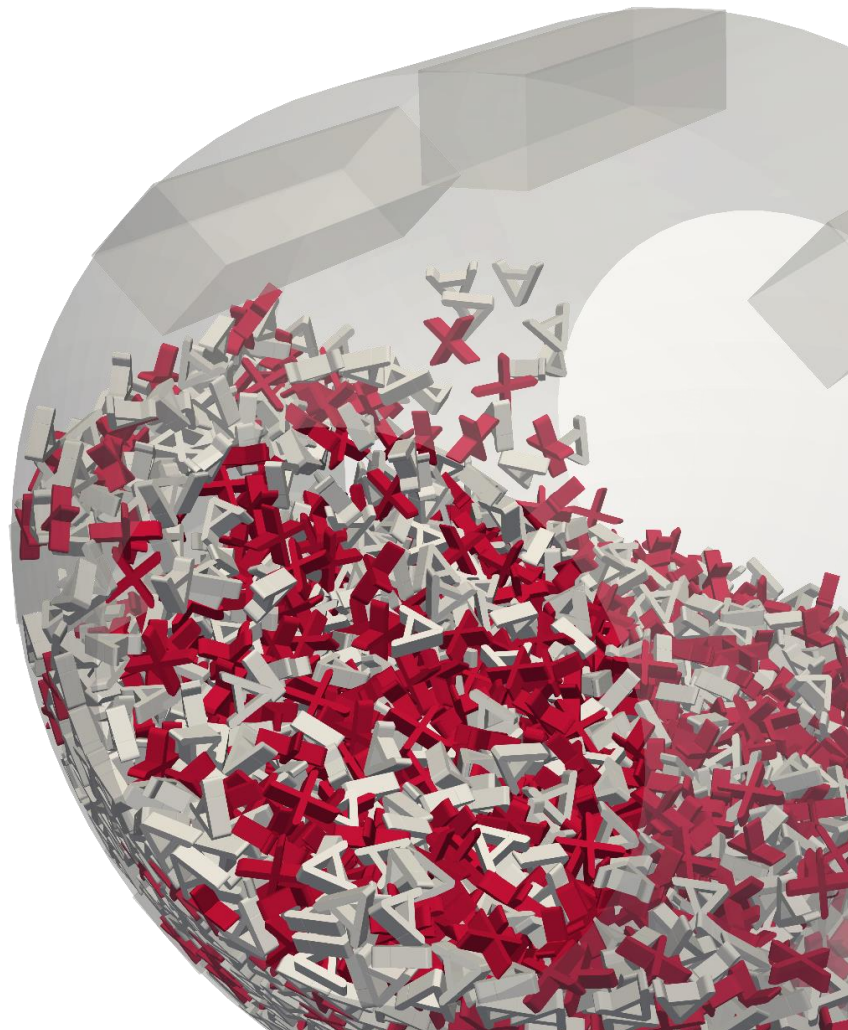
Please note that all features described in the feature list are available in Aspherix® Solver. Most features are also available in Aspherix® GUI but for technical reasons there are some restrictions.

### License usage & Installations

- Arbitrarily many installations on arbitrarily many systems allowed within organisation of Customer, license only restricts number of active processes
- Each license can be used on all supported OS

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# FEATURE LIST DETAILS





## FEATURE LIST - PHYSICS MODELS

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### 6 degrees of freedom solver

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- mesh module stress 6dof

### Body forces

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- enable buoyancy
- enable gravity
- freeze<sup>S</sup>

### Bond models

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- bond
- bond relativ

### Cohesion

---

- adaptive
- asphalt<sup>+</sup>
- bond
- bond relativ
- easo capillary viscous
- fiber<sup>+</sup>
- fiber buckle base<sup>+</sup>
- fiber plastic base<sup>+</sup>
- fiber wet base<sup>+</sup>
- general liquid bridge (normal: adams\_perchard, pitois, washino, washino\_powerlaw; tangential: goldman, xu, washino, xu\_powerlaw)
- lubrication
- powder<sup>+</sup>
- sjkr
- sjkr selective
- sjkr temp
- sjkr time dependent
- sjkr2
- washino capillary viscous



## FEATURE LIST - PHYSICS MODELS

---

### Damping

---

- cundall damping

### Drag forces

---

- const Cd
- DiFelice
- Schiller Naumann
- Zastawny

### Electricity

---

- enable\_electrical\_conductivity<sup>+</sup>

### Equipment wear and attrition

---

- archard
- finnie
- mesh stress wear

### Fast DEM

---

- addforce steadystate<sup>S+</sup>
- addforce steadystate experimental<sup>S+</sup>
- fast heat conduction<sup>S+</sup>

### Fiber cutting

---

- mesh module cutting<sup>+</sup>

### Fiber models

---

- fiber<sup>+</sup>
- fiber buckle base<sup>+</sup>
- fiber plastic base<sup>+</sup>
- fiber wet base<sup>+</sup>



## FEATURE LIST - PHYSICS MODELS

---

### Heat transfer

---

- enable heat conduction
- mesh heat transfer
- roasting<sup>+</sup>
- shell<sup>S</sup>
- surface heating

### Liquid bridges and liquid transport

---

- addliquid wall<sup>S</sup>
- easo capillary viscous
- general liquid bridge (normal: adams\_perchard, pitois, washino, washino\_powerlaw; tangential: goldman, xu, washino, xu\_powerlaw)
- liquid transport
- liquid transport evaporation
- liquid transport porous
- liquid transport sponge
- mesh module liquid transfer
- washino capillary viscous

### Magnetic dipole

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- addforce magnetic<sup>+</sup>

### Mass transfer and chemical reactions

---

- change size
- change size multisphere
- change size superquadric
- change size superquadric anisotropic
- melting<sup>+</sup>
- melting (shell model)<sup>S+</sup>



## FEATURE LIST - PHYSICS MODELS

### Material property models

- constant material properties
- custom materials<sup>S+</sup>
- interdependent material properties<sup>S</sup>
- material interaction properties
- material properties
- materials

### Mesh deformation

- mesh module stress deform

### Normal models

- hertz
- hertz fragmentation bruchmueller
- hertz fragmentation bruchmueller unresolved
- hertz stiffness
- hertz time dependent
- hertz velocity dependent<sup>S</sup>
- hooke
- hooke hysteresis
- hooke scale invariant
- hooke stiffness
- jkr
- jkr/general
- thornton-ning

### Pair styles

- hybrid<sup>S</sup>
- hybrid overlay<sup>S</sup>
- particle contact model
- stokes dynamics<sup>S</sup>





## FEATURE LIST - PHYSICS MODELS

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### Particle breakage and attrition

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- hertz fragmentation bruchmueller
- hertz fragmentation bruchmueller unresolved
- history attrition
- history attrition angle

### Particle deformation

---

- multicontact halfspace
- surface model multicontact

### Powder compaction

---

- powder cluster model<sup>+</sup>

### Rolling friction

---

- cdt
- epsd
- epsd2
- epsd3
- simplistic

### Sedimentation

---

- mesh module contact deletion<sup>S</sup>

### Spray coating

---

- DEM spray particles<sup>S+</sup>
- detect surface
- liquid transport
- liquid transport evaporation



### Tangential models

---

- |                                |                               |
|--------------------------------|-------------------------------|
| • burgers asphalt <sup>+</sup> | • history powder <sup>+</sup> |
| • history                      | • history tempdep             |
| • history attrition            | • history time dependent      |
| • history attrition angle      | • no history                  |



### Mesh

---

- volume vtk<sup>S</sup>

### Mesh controllers

---

- mesh control<sup>S</sup>
- mesh module stress 6dof
- mesh module stress servo
- mesh mover file
- mesh mover linear
- mesh mover rotation

### Mesh import

---

- mesh
- mesh modules

### Mesh manipulation

---

- defeaturing<sup>S</sup>
- mesh module motion
- mesh module stress deform

### Mesh modules

---

- mesh 6dof external (Simulink/Simscape, MSC Adams)<sup>S+</sup>
- mesh heat transfer
- mesh module binning<sup>S</sup>
- mesh module contact deletion<sup>S</sup>
- mesh module cutting<sup>+</sup>
- mesh module liquid transfer
- mesh module stress 6dof
- mesh module stress contact
- mesh module stress deform
- mesh module stress servo



### Region

---

- |             |            |
|-------------|------------|
| • block     | • prism    |
| • cone      | • sphere   |
| • cylinder  | • subtract |
| • intersect | • union    |
| • mesh vtk  | • wedge    |
| • plane     |            |

### Walls

---

- |                        |                                  |
|------------------------|----------------------------------|
| • primitive wall       | • wall reflect <sup>S</sup>      |
| • sieving <sup>+</sup> | • wall reflect mesh <sup>S</sup> |
| • wall contact model   |                                  |



## FEATURE LIST - FUNCTIONALITIES

---

### Boundary conditions

---

- boundary conditions
- simulation domain

### Integration

---

- integrator
- nonspherical integrator  
woodem
- limit\_velocity
- nve sphere limit<sup>S</sup>
- nonspherical integrator  
predictor/corrector
- simulate
- nonspherical integrator  
richardson
- simulation timestep
- nonspherical integrator  
symplectic

### Neighbor list

---

- multilevel neighborlist
- neighbor list

### Particle deletion

---

- delete particles
- remove<sup>S</sup>
- mesh module contact  
deletion<sup>S</sup>



## FEATURE LIST - FUNCTIONALITIES

---

### Particle insertion

---

- |                                |   |
|--------------------------------|---|
| • create particles             | • insert stream predefined <sup>S</sup> |
| • dense packing (experimental) | • insert stream regionfill              |
| • dilute packing               | • insertion                             |
| • insert rate in region        | • particle_distribution                 |
| • insert stream moving         | • prepare packing <sup>S</sup>          |

### Particle manipulation

---

- |   |                                |
|---|--------------------------------|
| • addforce steadystate <sup>S+</sup>              | • planeforce <sup>S</sup>      |
| • addforce steadystate experimental <sup>S+</sup> | • replicate <sup>S</sup>       |
| • change size                                     | • set <sup>S</sup>             |
| • change size multisphere                         | • set force                    |
| • change size superquadric                        | • set multisphere <sup>S</sup> |
| • change size superquadric anisotropic            | • set velocity                 |
| • change type                                     | • torque <sup>S</sup>          |
| • displace particles <sup>S</sup>                 | • update_particle              |
| • group   | • variable <sup>S</sup>        |
| • grow particles                                  | • velocity <sup>S</sup>        |
| • lineforce <sup>S</sup>                          | • viscous                      |
| • move  |                                |



## FEATURE LIST - POSTPROCESSING

---

### Collision statistics

---

- contact atom counter<sup>S</sup>
- coordination number

### Energy balance

---

- calculate energy dissipated
- calculate energy wall elastic cohesion
- calculate energy elastic cohesion
- calculate energy wall elastic normal
- calculate energy elastic normal
- calculate external\_work
- calculate energy wall dissipated

### Fiber data

---

- bond fiber<sup>S+</sup>
- bond fiber topology<sup>S+</sup>

### Intra-particle coating variability

---

- dump particle meshed<sup>S</sup>

### Mesh residence time

---

- mesh module stress contact

### Meshes

---

- calculate external\_work
- mesh area
- mesh velocity



## FEATURE LIST - POSTPROCESSING

---

### Other

---

- check timestep

### Particle data

---

- |                                      |                                     |
|--------------------------------------|-------------------------------------|
| • calculate                          | • calculate spatial average         |
| • calculate average                  | • calculate spatio temporal average |
| • calculate center of mass           | • calculate sum                     |
| • calculate marked particles         | • calculate temporal average        |
| • calculate massflow                 | • calculate voronoi decomposition   |
| • calculate maximum                  | • calculate wall contact network    |
| • calculate minimum                  | • cross-section                     |
| • calculate mixing index             | • group                             |
| • calculate particle contact network | • reduce <sup>S</sup>               |
| • calculate residence distance       | • store state <sup>S</sup>          |
| • calculate residence time           | • variable <sup>S</sup>             |

### Residence time distribution

---

- |                                |                           |
|--------------------------------|---------------------------|
| • calculate residence distance | • mark inserted particles |
| • calculate residence time     | • mark particles          |





## FEATURE LIST - POSTPROCESSING

---

### Spatial and temporal averaging

---

- calculate
- calculate average
- calculate center of mass
- calculate maximum
- calculate minimum
- calculate mixing index
- calculate spatial average
- calculate spatio temporal average
- calculate sum
- calculate temporal average
- calculate voronoi decomposition
- detect steady state<sup>S</sup>

### Stresses and force network

---

- calculate particle contact network
- calculate wall contact network
- mesh module binning<sup>S</sup>
- mesh module stress\_average
- pressure simplistic



### Meshes

---

- modify output settings<sup>S</sup>
- output settings

### Reader

---

- read

### Write expert

---

- dump euler vtk<sup>S</sup>
- dump field vtk cell<sup>S</sup>
- dump image<sup>S</sup>
- dump mesh volume vtk<sup>S</sup>
- dump region neighbor field list<sup>S</sup>
- write data

### Write standard

---

- dump decomposition
- dump particle meshed<sup>S</sup>
- modify output settings<sup>S</sup>
- origin<sup>S</sup>
- output settings
- write output timestep
- write restart
- write to file<sup>S</sup>
- write to terminal timestep



### Coarsegraining

---

- coarsegraining

### Loadbalancing

---

- rcb loadbalancing

### Parallelization

---

- partitions<sup>S</sup>
- processors



## FEATURE LIST - COUPLING INTERFACE

---

### CFD 1-way coupling

---

- dragforce field compressible<sup>S+</sup>
- dragtorque field compressible<sup>S+</sup>
- enable one-way coupling
- enable one-way coupling moving reference frame (MRF)
- enable one-way coupling transient
- enable one-way coupling with rotating zone<sup>+</sup>
- enable transient one-way coupling<sup>+</sup>
- temperature fluid field<sup>+</sup>

### CFD 4-way coupling (Linux only)

---

- include foam variables<sup>S+</sup>

### FEM coupling

---

- Howto for FEM coupling (Linux only)<sup>S+</sup>

### FEM coupling (Linux only)

---

- FEM coupling to Elmer<sup>S+</sup>

### MBD coupling

---

- mesh 6dof external (Simulink/Simscape, MSC Adams)<sup>S+</sup>



### API: C++

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- aspherix<sup>S+</sup>

### API: Python

---

- aspherix<sup>S+</sup>

### Custom contact models

---

- aspherix contact model external<sup>S+</sup>
- aspherix contact model external connector<sup>S+</sup>
- aspherix particle interaction<sup>S+</sup>
- normal model external<sup>S+</sup>

### Custom equations

---

- aspherix fix<sup>S+</sup>
- aspherix fix external<sup>S+</sup>

### Custom mesh access

---

- aspherix mesh<sup>S+</sup>
- aspherix mesh element<sup>S+</sup>
- aspherix mesh element list<sup>S+</sup>

### Custom particle properties

---

- aspherix global properties<sup>S+</sup>
- aspherix quaternion<sup>S+</sup>
- aspherix particle<sup>S+</sup>
- aspherix variable<sup>S+</sup>
- aspherix particle list<sup>S+</sup>
- aspherix vector<sup>S+</sup>