ASPHERIX

PRODUCT INFORMATION
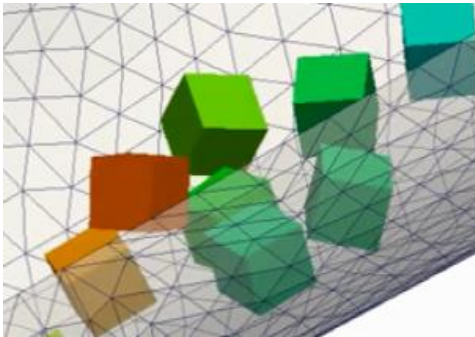
DCS COMPUTING
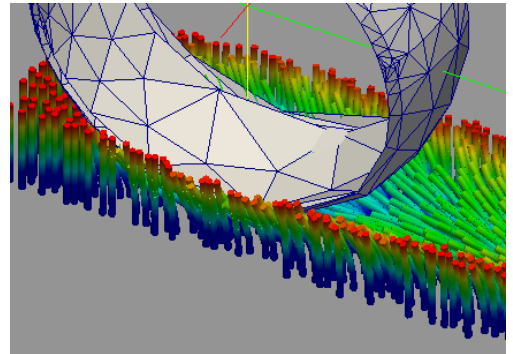
PARTICLE SHAPES

Aspherix® supports a large variety of particle shapes

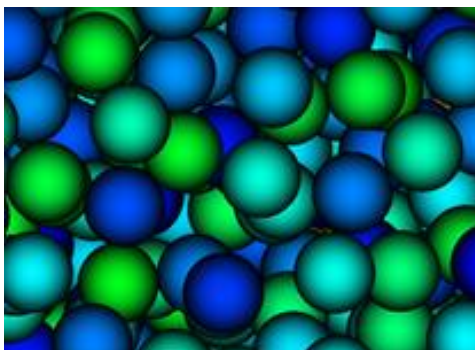### Convex triangulated

Fiber+ and bonded

Concave triangulated

Multisphere
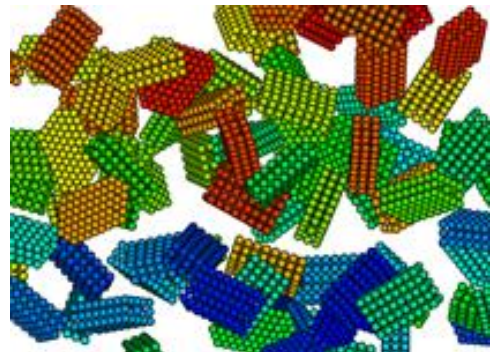
Sphere

Box, cylinder, ellipsoid
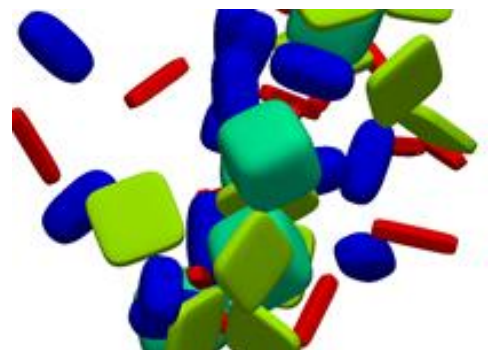
S functionality available in Aspherix® Solver only
* Functionality not available in Aspherix® Basic

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HIGHLIGHTS

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

6 degree of freedom solver
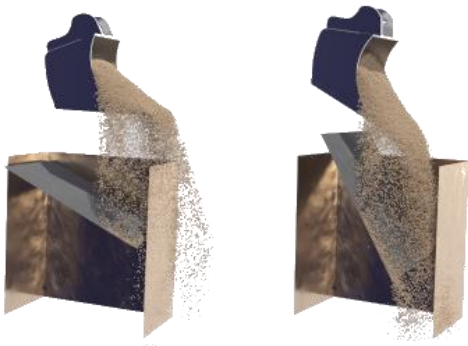
Powder compaction[+]
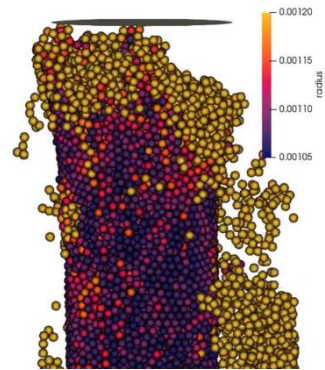
Cohesion models
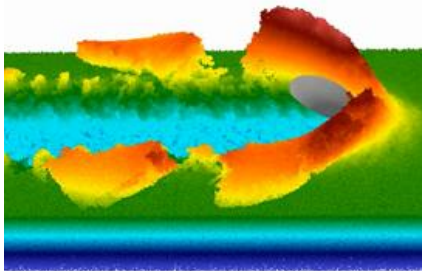
Loadbalancing
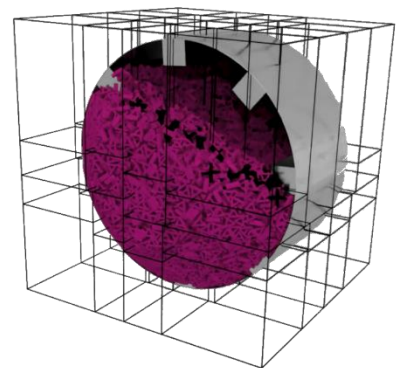
Spray coating
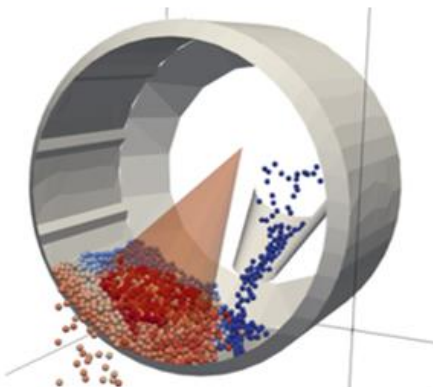
Coupling interface[+]
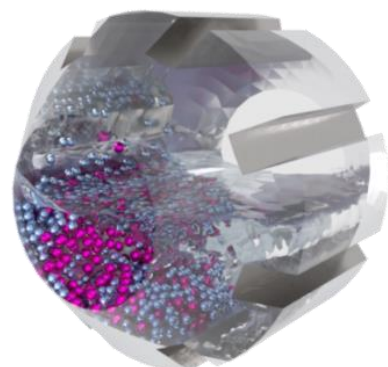
[S] functionality available in Aspherix® Solver only
* Functionality not available in Aspherix® Basic

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COMPONENTS AND OPTIONS

Aspherix® consists of the following components:

Strong simulation engine for DEM
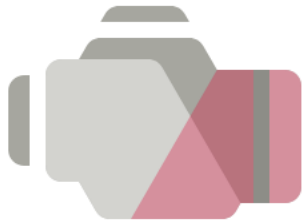
Easy to use GUI for DEM

GUI workflow for coupled CFD-DEM simulations

Aspherix® runs on:

Desktop machines

Clusters

Clouds

ASPHERIX® is available for Linux and Windows

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SYSTEM REQUIREMENTS

Aspherix® Solver - MPI

Windows

- Delivered with installer

Linux

- MPI is required

- has to support MPI 3 standard (e.g. min OpenMPI 1.8, or MPICH 3.0)

Aspherix® GUI

- OpenGL library (version 3.2 or higher)

Aspherix® Solver - API

Linux

- cmake is required (min cmake 3.9)

Aspherix® Calibration – for Python Support

- Python is required (min Python 3.8)

System requirements - Operating systems

- Windows 10, 11
- Ubuntu 20.04, 22.04, 24.04
- Centos Stream 9
- Rocky Linux 9
- Red Hat 9
- Suse Enterprise 12,15; Open Suse tumbleweed
- Amazon Linux 2023
- GUI requires glibc 2.17 or higher

Operating Systems – Special cases

- Centos Stream 8 (Aspherix® Solver ONLY, GUI support not guaranteed)

- Windows Server 2019, 2022 (Aspherix® GUI needs OpenGL 3.2)

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SYSTEM REQUIREMENTS

Prerequisites for coupling interfaces only

CFDEMcoupling:

- cmake 3.10

- OpenFOAM 10*

- Linux only (systems as specified on previous page), Windows subsystem for Linux allows for usage on Windows

- 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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* Functionality not available in Aspherix® Basic
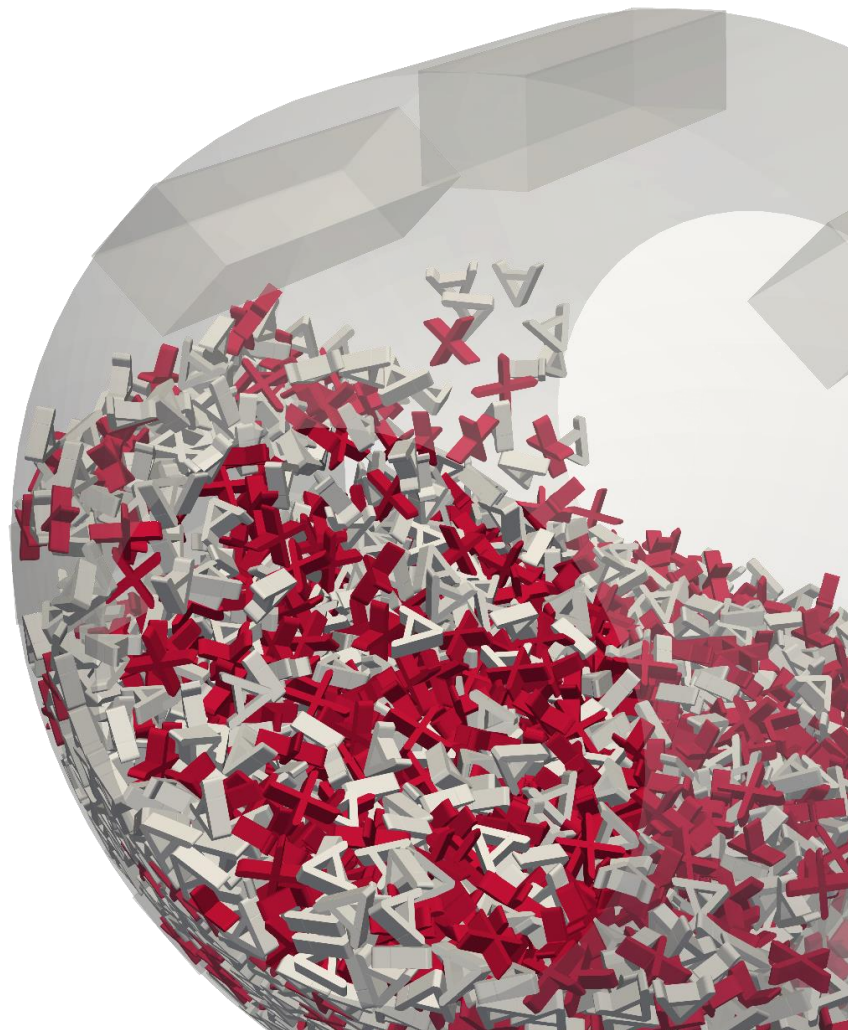
FEATURE LIST OVERVIEW

Physics models

6 degrees of freedom solver	body forces
bond models	bubble models[s]
cohesion	damping
drag forces	electricity*
equipment wear and attrition	fast DEM[s]*
fiber cutting*	fiber models*
heat transfer	liquid bridges and liquid transport
magnetic dipole*	mass transfer and chemical reactions
material property models	mesh deformation
normal models	pair styles
particle breakage and attrition	particle deformation
photon reflection*	powder compaction*
rolling friction	sedimentation (CFD 4-way coupling only)
spray coating	surface models
tangential models	

Particle shapes

bonded	box
capsule	concave triangulated
convex triangulated	cylinder
ellipsoid	fiber*
fragments	general
multisphere	rod
sphere	superquadric
tablet	

Meshes and geometry

mesh controllers	mesh deformation
mesh import	mesh manipulation
mesh modules	region
walls	

Functionalities

boundary conditions	integration
neighbor list	particle deletion
particle insertion	particle manipulation

^{S} functionality available in Aspherix® Solver only
* Functionality not available in Aspherix® Basic

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Postprocessing

collision statistics	energy balance
fiber data[s]*	mesh residence time
meshes	particle data
post simulation evaluation	residence time distribution
scalability and speed	spatial and temporal averaging
stresses and force network	

IO

meshes	reader
write expert	write standard

Scalability and speed

coarsegraining	loadbalancing
parallelization	resizing[s]*

Coupling interface

CFD 1-way coupling	CFD 4-way coupling (Linux only)*
FEM coupling (Linux only)[s]*	MBD couplings[s]*
electric field coupling*	

FEATURE LIST - OVERVIEW

Api[s]*

API: C++[s]*	API: Python[s]*
custom contact models[s]*	custom equations[s]*
custom mesh access[s]*	custom particle properties[s]*

[s] functionality available in Aspherix® Solver only
* Functionality not available in Aspherix® Basic

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FEATURE LIST DETAILS
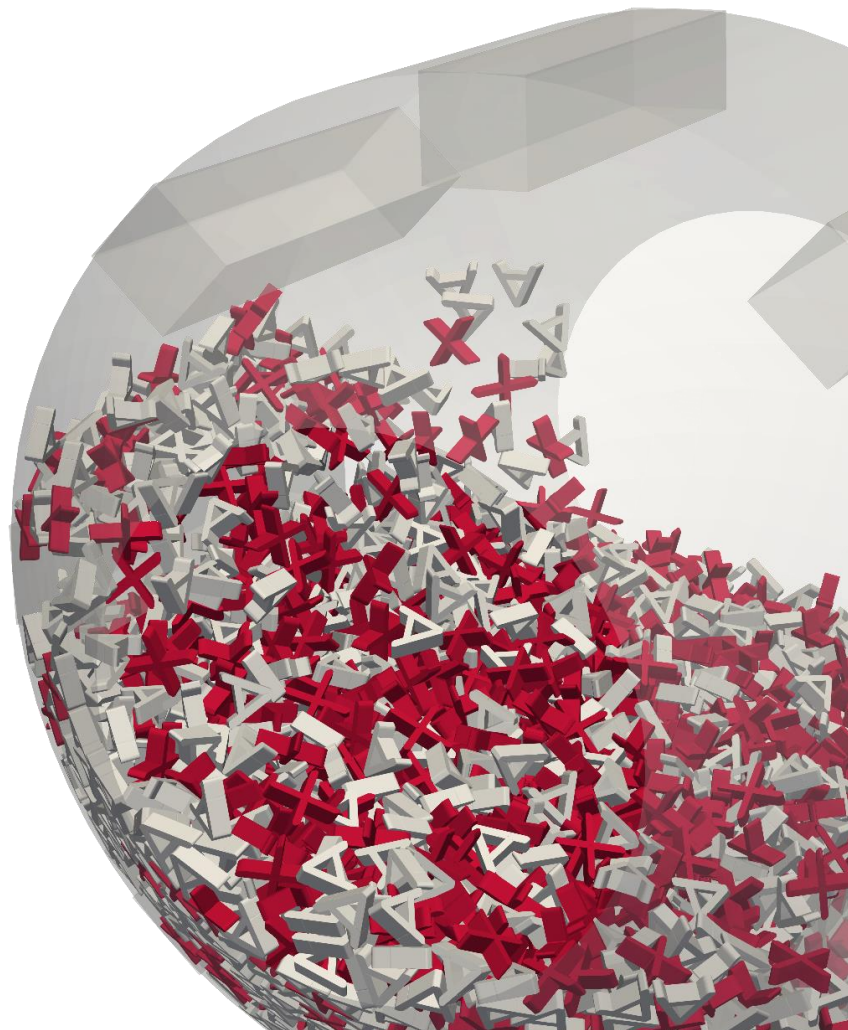
6 degrees of freedom solver

mesh module 6dof	

Body forces

freeze[s]	buoyancy
gravity	simplified fluid model[s]

Bond models

bond	bond relative

Bubble models[s]

bubble[s]	bubble breakup[s]
bubble coalescence[s]	

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FEATURE LIST - PHYSICS MODELS

Cohesion

adaptive	asphalt*
bond	bond relative
bubble coalescence[s]	easo capillary viscous
fiber*	fiber buckle base*
fiber plastic base*	fiber wet base*
general liquid bridge (normal: adams_perchard, pitois, washino, washino_powerlaw; tangential: goldman, xu, washino, xu_powerlaw)	Liquid bridge solidification
lubrication	sjkr
sjkr2	powder*
sjkr selective	sjkr temp
sjkr time dependent	washino capillary viscous

Damping

cundall damping	

Drag forces

DiFelice	Schiller Naumann
Zastawny	const Cd

[s] functionality available in Aspherix® Solver only
* Functionality not available in Aspherix® Basic

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FEATURE LIST - PHYSICS MODELS

Electricity*

enable_electrical_conductivity*	

Equipment wear and attrition

archard wear model	finnie wear model
mesh wear	

Fast dem^s*

addforce steadystate^s*	fast heat conduction^s*
addforce steadystate experimental^s*	

Fiber cutting*

mesh module cutting*	

Fiber models*

fiber*	fiber buckle base*
fiber plastic base*	fiber wet base*

Heat transfer

heat conduction	particle melting*
surface heating	roasting*
mesh heat transfer	radiation

Liquid bridges and liquid transport

addliquid walls	liquid transport
liquid transport evaporation	liquid transport porous
liquid transport sponge	easo capillary viscous
general liquid bridge (normal: adams_perchard, pitois, washino, washino_powerlaw; tangential: goldman, xu, washino, xu_powerlaw)	Liquid bridge solidification
washino capillary viscous	mesh module liquid transfer

Magnetic dipole*

addforce magnetic*	

Mass transfer and chemical reactions

change size	change size multisphere
change size superquadric	change size superquadric anisotropic

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FEATURE LIST - PHYSICS MODELS

Material property models

composition properties[s]	custom material properties[s]
material interaction properties	material properties
materials	custom materials[s]*
interdependent material properties[s]	

Mesh deformation

mesh module deform	

Normal models

adhesive elasto plastic	hertz
hertz fragmentation bruchmueller	hertz fragmentation bruchmueller unresolved
hertz stiffness	hertz time dependent
hertz velocity dependent[s]	hooke
hooke hysteresis	hooke scale invariant
hooke stiffness	jkr
jkr/general	thornton-ning

Pair styles

hybrid[s]	hybrid overlay[s]
stokes dynamics[s]	particle contact model

[s] functionality available in Aspherix® Solver only
* Functionality not available in Aspherix® Basic

FEATURE LIST - PHYSICS MODELS

Particle breakage and attrition

particle breakage force	hertz fragmentation bruchmueller
hertz fragmentation bruchmueller unresolved	history attrition
history attrition angle	

Particle deformation

multicontact halfspace	surface model multicontact

Photon reflection*

photon properties*	

Powder compaction*

powder cluster model*	

Rolling friction

simplistic	cdt
epsd	epsd2
epsd3	

FEATURE LIST - PHYSICS MODELS

Sedimentation (CFD 4-way coupling only)

sedimentation	mesh module contact deletion[s]

Spray coating

detect surface	liquid transport
liquid transport evaporation	DEM spray particles*
different spray nozzle shapes*	spray particle to surface film conversion*

Surface models

surface model multicontact	superquadric orthogonal

Tangential models

adhesive_elasto_plastic	burgers asphalt*
history	history attrition
history attrition angle	history powder*
history tempdep	history time dependent
no history	

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FEATURE LIST - MESHES AND GEOMETRY

Mesh controllers

mesh mover linear	mesh mover rotation
mesh mover file	mesh module 6dof
mesh module servo	

Mesh deformation

mesh module deform	

Mesh import

mesh	

Mesh manipulation

defeaturing[s]	mesh module deform
mesh module motion	

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Mesh modules

mesh module 6dof	mesh 6dof external (Simulink/Simscape, MSC Adams)[s]*
mesh module binning[s]	mesh module contact
mesh module contact deletion[s]	mesh module cutting*
mesh module deform	mesh heat transfer
mesh module liquid transfer	mesh module motion
mesh module servo	mesh module stress_average
mesh wear	mesh modules

Region

block	cone
cylinder	halfspace
intersect	prism
sphere	subtract
union	wedge
mesh vtk	

Walls

wall reflect[s]	sieving*
wall reflect mesh[s]	primitive wall
wall contact model	

[s] functionality available in Aspherix® Solver only
* Functionality not available in Aspherix® Basic

FEATURE LIST - FUNCTIONALITIES

Boundary conditions

boundary conditions	simulation domain

Integration

nve sphere limit[s]	reset timestep[s]
integrator	nonspherical integrator predictor/corrector
nonspherical integrator richardson	nonspherical integrator symplectic
nonspherical integrator woodem	velocity limit
simulate	simulation timestep

Neighbor list

multilevel neighborlist	neighbor list

Particle deletion

delete particles	mesh module contact deletion[s]
remove[s]	

Particle insertion

create particles	insert stream predefined[s]
prepare packing[s]	dense packing (experimental)
dilute packing	insertion
insertion laser*	insertion pack
insertion rate in region	insertion spray nozzle
insertion stream	insertion stream regionfill
particle_distribution	

[s] functionality available in Aspherix® Solver only
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Particle manipulation

displace particles[s]	add force
lineforce[s]	move
planeforce[s]	set force
viscous	replicate[s]
set[s]	variable[s]
velocity[s]	group definition
group deletion[s]	addforce steadystate[s]*
add weighted force	change size
change size multisphere	change size superquadric
change size superquadric anisotropic	change type[s]
grow particles	set velocity
addforce steadystate experimental[s]*	set multisphere[s]
torque[s]	update particle

[s] functionality available in Aspherix® Solver only
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FEATURE LIST - POSTPROCESSING

Collision statistics

calculate collision statistics	coordination number

Energy balance

calculate external_work	calculate energy dissipated
calculate energy wall dissipated	calculate energy elastic cohesion
calculate energy elastic normal	calculate energy wall elastic cohesion
calculate energy wall elastic normal	

Fiber data[s]*

bond fiber topology[s]*	bond fiber[s]*

Mesh residence time

mesh module contact	

Meshes

calculate average	calculate external_work
calculate maximum	calculate minimum
calculate sum	mesh area
reduce[s]	mesh velocity

Particle data

reduce[s]	store state[s]
variable[s]	calculate
calculate average	calculate center of mass
calculate marked particles	calculate massflow
calculate maximum	calculate minimum
calculate mixing index	calculate particle bond network
calculate particle contact network	calculate residence distance
calculate residence time	calculate spatial average
calculate spatio temporal average	calculate strain
calculate stress	calculate sum
calculate temporal average	calculate voronoi decomposition
calculate wall bond network	calculate wall contact network
cross-section	group definition
group deletion[s]	

Post simulation evaluation

calculate massflow	calculate residence time
calculate spatial average	write to file[s]

Residence time distribution

calculate residence distance	calculate residence time
mark inserted particles	mark particles

FEATURE LIST - POSTPROCESSING

Scalability and speed

check timestep	

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[s]
temporal steady state detection[s]	continuum weighted average[s]

Stresses and force network

calculate particle bond network	calculate particle contact network
calculate wall bond network	calculate wall contact network
pressure simplistic	mesh module binning[s]
mesh module stress_average	

[s] functionality available in Aspherix® Solver only
* Functionality not available in Aspherix® Basic

FEATURE LIST - IO

Meshes

output settings	modify output settings[s]

Reader

read	reader pvd[s]

Write expert

dump image[s]	dump modify[s]
modify dump vtk[s]	write data
dump euler vtk[s]	dump field vtk cell[s]
dump mesh volume vtk[s]	dump region neighbor field list[s]

Write standard

origin[s]	restart[s]
status[s]	status log[s]
status modify[s]	status style[s]
undump[s]	write restart
write on signal[s]	dump decomposition
output settings	write meshed particles
modify output settings[s]	write output timestep
write to file[s]	write to terminal timestep

FEATURE LIST - SCALABILITY AND SPEED

Coarsegraining

coarsegraining	

Loadbalancing

rcb loadbalancing	

Parallelization

partitions^s	processors

Resizing^{s*}

dynamic coarsening^{s*}	dynamic refinement^{s*}

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FEATURE LIST - COUPLING INTERFACE

CFD 1-way coupling

velocity fields	resample vtk[s]
compressible flows*	incompressible flows
one-way coupling with rotating zone*	temperature fields*
transient one-way coupling*	

CFD 4-way coupling (linux only)*

include foam variables[s]*	cfd coupling*
DEM drag*	

FEM coupling (linux only)[s]*

FEM coupling to Elmer[s]*	Howto for FEM coupling (Linux only)[s]*

MBD coupling[s]*

mesh 6dof external (Simulink/Simscape, MSC Adams)[s]*	

Electric field coupling*

electric field*	

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FEATURE LIST - API[S*]

API: C++[S*]

aspherix[S*]	

API: Python[S*]

aspherix[S*]	

Custom contact models[S*]

aspherix contact model external[S*]	aspherix particle interaction[S*]
aspherix contact model external connector[S*]	normal model external[S*]

Custom equations[S*]

aspherix fix[S*]	aspherix fix external[S*]

Custom mesh access[S*]

aspherix mesh[S*]	aspherix mesh element[S*]
aspherix mesh element list[S*]	

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Custom particle properties[s*]

aspherix global properties[s*]	aspherix particle[s*]
aspherix particle list[s*]	aspherix quaternion[s*]
aspherix variable[s*]	aspherix vector[s*]

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