

ASPHERIX

PRODUCT INFORMATION



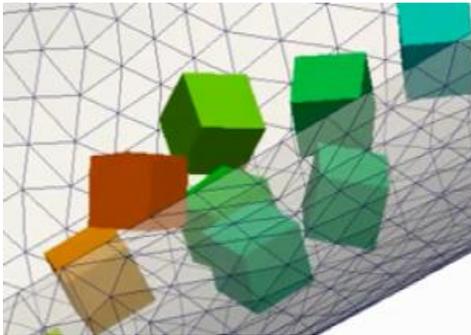
DCS
COMPUTING



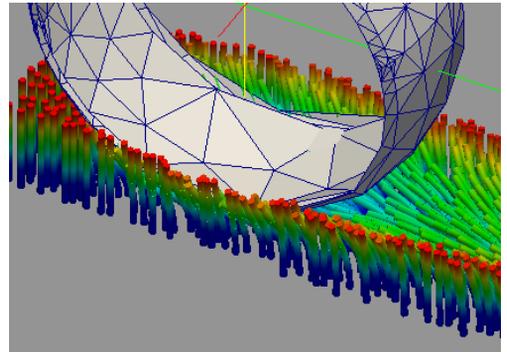
Aspherix® supports a large variety of particle shapes



Convex triangulated



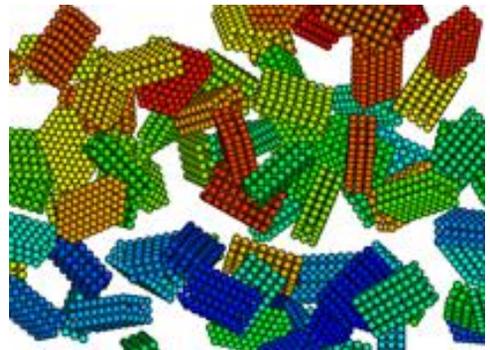
Fiber+ and bonded



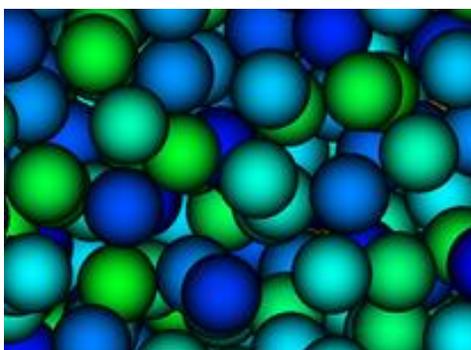
Concave triangulated



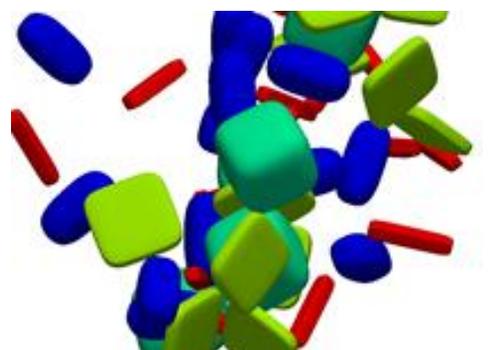
Multisphere



Sphere



Box, cylinder, ellipsoid



[§] functionality available in Aspherix® Solver only
^{*} Functionality not available in Aspherix® Basic

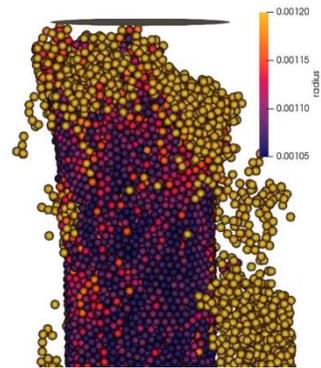


Aspherix® has numerous cutting-edge physics models and great options for integration. Here are some highlights:

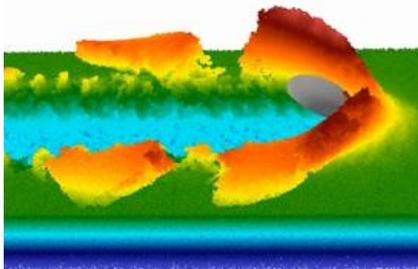
6 degree of freedom solver



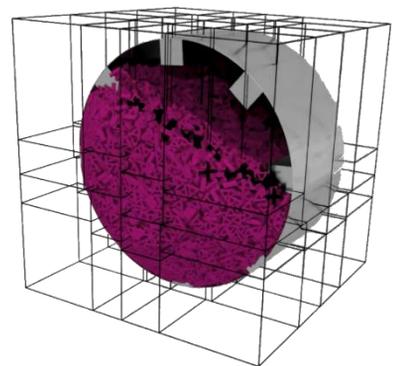
Powder compaction⁺



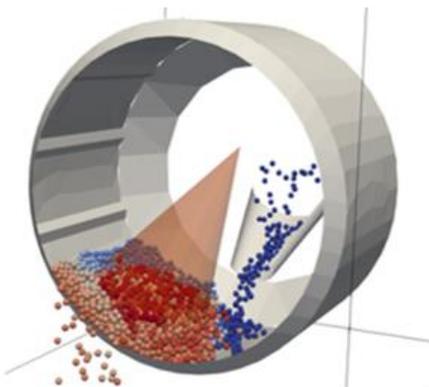
Cohesion models



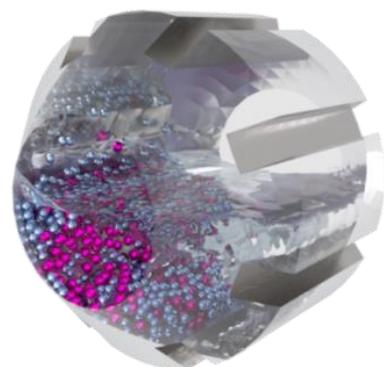
Loadbalancing



Spray coating



Coupling interface⁺



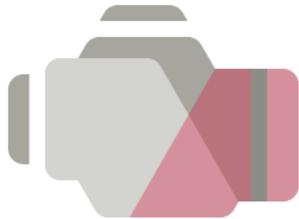
[§] functionality available in Aspherix® Solver only
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COMPONENTS AND OPTIONS

Aspherix® consists of the following components:

Strong simulation engine for DEM



Easy to use GUI for DEM



GUI workflow for coupled CFD-DEM simulations

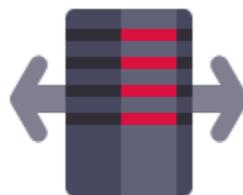


Aspherix® runs on:

Desktop machines



Clusters



Clouds



ASPHERIX® is available for Linux and Windows



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 18.04, 20.04, 22.04
- Centos Stream 9
- Rocky Linux 9
- Red Hat 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, GUI support not guaranteed)
- Windows Server 2019, 2022 (Aspherix® GUI needs OpenGL 3.2)



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.

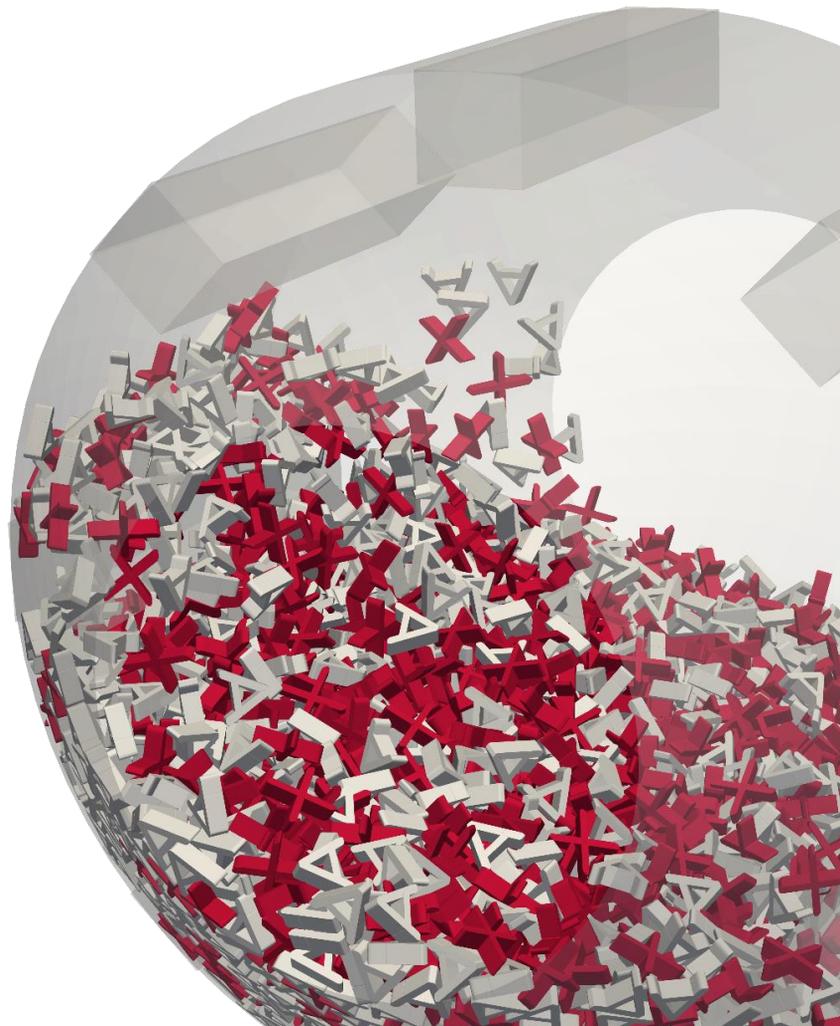
License usage & Installations

- 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

**This offering is not approved or endorsed by OpenCFD Limited, producer and distributor of the OpenFOAM software via www.openfoam.com, and owner of the OPENFOAM® and OpenCFD® trade marks.*

[§] functionality available in Aspherix® Solver only
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FEATURE LIST OVERVIEW





FEATURE LIST - OVERVIEW

Physics models

6 degrees of freedom solver	body forces
bond models	bubble models [§]
cohesion	damping
drag forces	electricity*
equipment wear and attrition	fast DEM ^{§*}
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
spray coating	surface models
tangential models	

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



FEATURE LIST - OVERVIEW

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 import
mesh manipulation	mesh modules
region	walls

Functionalities

boundary conditions	integration
neighbor list	particle deletion
particle insertion	particle manipulation



FEATURE LIST - OVERVIEW

Postprocessing

collision statistics	energy balance
fiber data ^{s*}	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 (Linux only) ^{s*}	MBD coupling ^{s*}

^s functionality available in Aspherix® Solver only
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FEATURE LIST - OVERVIEW

Apis*

API: C++^{s*}

custom contact models^{s*}

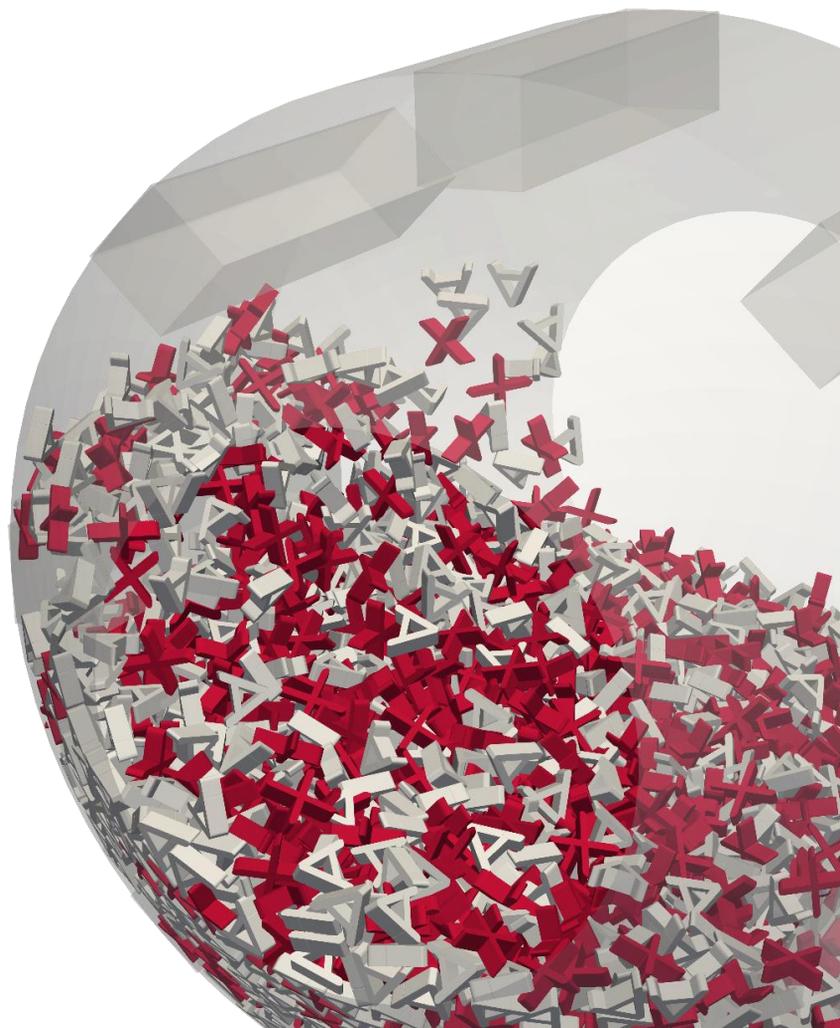
custom mesh access^{s*}

API: Python^{s*}

custom equations^{s*}

custom particle properties^{s*}

FEATURE LIST DETAILS





FEATURE LIST - PHYSICS MODELS

6 degrees of freedom solver

mesh module stress 6dof

Body forces

freeze^s

enable gravity

enable buoyancy

simplified fluid model^s

Bond models

bond

bond relative

Bubble models^s

bubble^s

bubble coalescences^s

bubble breakup^s

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



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)	lubrication
sjkr	sjkr2
powder*	sjkr selective
sjkr temp	sjkr time dependent
washino capillary viscous	

Damping

cundall damping	
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Drag forces

DiFelice	Schiller Naumann
Zastawny	const Cd

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



FEATURE LIST - PHYSICS MODELS

Electricity*

enable_electrical_conductivity*

Equipment wear and attrition

archard wear model

finnie wear model

mesh wear

Fast DEMs*

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*



FEATURE LIST - PHYSICS MODELS

Heat transfer

enable heat transfer	enable particle melting
surface heating	roasting*
mesh heat transfer	

Liquid bridges and liquid transport

addliquid wall ^s	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)	washino capillary viscous
mesh module liquid transfer	

Magnetic dipole*

addforce magnetic*	
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^s functionality available in Aspherix® Solver only
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FEATURE LIST - PHYSICS MODELS

Mass transfer and chemical reactions

change size

change size multisphere

change size superquadric

change size superquadric anisotropic

melting*

Material property models

custom material properties^s

material interaction properties

material properties

materials

custom materials^{s*}

interdependent material properties^s

Mesh deformation

mesh module deform



FEATURE LIST - PHYSICS MODELS

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

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



FEATURE LIST - PHYSICS MODELS

Photon reflection*

photon properties*	
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Powder compaction*

powder cluster model*	
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Rolling friction

simplistic	cdt
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epsd	epsd2
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epsd3	
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Sedimentation

sedimentation	mesh module contact deletion ^s
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Spray coating

detect surface	liquid transport
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liquid transport evaporation	DEM spray particles*
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different spray nozzle shapes*	spray particle to surface film conversion*
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FEATURE LIST - PHYSICS MODELS

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



Mesh controllers

mesh control ^s	mesh mover linear
mesh mover rotation	mesh mover file
mesh module stress 6dof	mesh module stress servo

Mesh import

mesh	
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Mesh manipulation

defeaturing ^s	mesh module stress deform
mesh module motion	

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

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



Region

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

Walls

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

[§] functionality available in Aspherix® Solver only
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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

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



FEATURE LIST - FUNCTIONALITIES

Particle insertion

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

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



FEATURE LIST - FUNCTIONALITIES

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	dynamic coarsening ^{s*}
dynamic refinement ^{s*}	addforce steadystate ^{s*}
add weighted force	change size
change size multisphere	change size superquadric
change size superquadric anisotropic	change type
grow particles	set velocity
addforce steadystate experimental ^{s*}	set multispheres ^s
torque ^s	update particle

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



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 fibers^{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



FEATURE LIST - POSTPROCESSING

Other

check timestep

Particle data

reduce^s

variable^s

calculate average

calculate marked particles

calculate maximum

calculate mixing index

calculate particle contact network

calculate residence time

calculate spatio temporal average

calculate temporal average

calculate wall bond network

cross-section

group deletion^s

calculate strain

store state^s

calculate

calculate center of mass

calculate massflow

calculate minimum

calculate particle bond network

calculate residence distance

calculate spatial average

calculate sum

calculate voronoi decomposition

calculate wall contact network

group definition

calculate stress

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 strain	calculate stress
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



Coarsegraining

coarsegraining	
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Loadbalancing

rcb loadbalancing	
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Parallelization

partitions ^s	processors
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FEATURE LIST - COUPLING INTERFACE

CFD 1-way coupling

enable one-way coupling	enable one-way coupling moving reference frame (MRF)
enable one-way coupling transient	dragforce field compressible ^{s*}
dragtorque field compressible ^{s*}	temperature fluid field*
resample vtk ^s	enable one-way coupling with rotating zone*
enable transient one-way coupling*	

CFD 4-way coupling (Linux only)*

include foam variables ^{s*}	enable cfd coupling*
enable DEM drag*	

FEM coupling (Linux only)^{s*}

FEM coupling to Elmer ^{s*}	Howto for FEM coupling (Linux only) ^{s*}
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MBD coupling^{s*}

mesh 6dof external (Simulink/Simscape, MSC Adams) ^{s*}	
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^s functionality available in Aspherix® Solver only
^{*} Functionality not available in Aspherix® Basic



FEATURE LIST - APIs*

API: C++^{s*}

aspherix^{s*}

API: Python^{s*}

aspherix^{s*}

Custom contact models^{s*}

aspherix contact model external^{s*}

aspherix contact model external
connector^{s*}

aspherix particle interaction^{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 list^{s*}

aspherix mesh element^{s*}

^s functionality available in Aspherix® Solver only
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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*}