~~WHAT IS~~ CLAIM~~ED IS~~:

1. An apparatus for nondestructive detection of an undissolved particle in a vessel that is at least partially filled with a fluid, the apparatus comprising:

(a) an imager configured to acquire time-series data representing a trajectory of the particle in the fluid; wherein the imager comprises a first sensor configured to detect a first image of at least part of the fluid at a first resolution and a first imaging speed; and

a second sensor configured to detect a first image of at least part of the fluid at a second resolution finer than the first resolution and a second imaging speed slower than the first imaging speed;

(b) a memory operably coupled to the imager and configured to store the time-series data; and

(c) a processor operably coupled to the memory and configured to the particle by:

(i) reversing a time ordering of the time-series data to form reversed time-series data;

(ii) estimating the trajectory of the particle from the reversed time-series data; and

(iii) determining a presence or type of the particle based on the trajectory.

2. An apparatus for nondestructive detection of an undissolved particle in a vessel that is at least partially filled with a fluid, the apparatus comprising:

(a) an imager configured to acquire time-series data representing a trajectory of the particle in the fluid; wherein the imager comprises:

a first sensor configured to detect a first image of at least part of the fluid at a first magnification; and

a second sensor configured to detect a second image of at least part of the fluid at a second magnification greater than the first magnification;

(b) a memory operably coupled to the imager and configured to store the time-series data; and

(c) a processor operably coupled to the memory and configured to the particle by:

(i) reversing a time ordering of the time-series data to form reversed time-series data;

(ii) estimating the trajectory of the particle from the reversed time-series data; and

(iii) determining a presence or type of the particle based on the trajectory.

~~2.~~3. The apparatus of claim 1 or 2, wherein the particle has a minimum width of about 1 µm to about 400 µm.

~~3.~~4. The apparatus of claim 1 or 2, wherein the particle has a minimum width of about 75 to about 100 µm.

~~4.~~5. The apparatus of claim 1 or 2, wherein the particle has a minimum width of about 1 µm or greater.

~~5.~~6. The apparatus of claim 1 or 2, wherein the particle comprises a protein aggregate.

~~6. The apparatus of claim 1, wherein the imager comprises a telecentric lens to project an image of the particle onto a sensor.~~

~~7. The apparatus of claim 1, wherein the imager comprises a lens with a variable focal length.~~

~~8. The apparatus of claim 1, wherein the imager comprises:~~
~~a sensor configured to detect an image of the particle; and~~
~~a cooling device for cooling the sensor.~~

~~9. The apparatus of claim 1, wherein the imager comprises:~~
~~a sensor configured to detect an image of the particle; and~~
~~a corrective optical element disposed between the particle and the sensor and configured to compensate for distortion of the image of the particle caused by curvature of the vessel.~~

10. The apparatus of claim 8, wherein the corrective optical element comprises a lens comprising a refractive material having a first cylindrical surface with a first radius of curvature and a second cylindrical surface having a second radius of curvature.

11. The apparatus of claim 10, wherein the first and second radii of curvature are different.

12. The apparatus of claim 8, wherein the imager further comprises a telecentric lens disposed between the sensor and the vessel, and wherein the corrective optical element substantially corrects for magnification of the image caused by curvature of the vessel.

13. The apparatus of claim 1, wherein the imager comprises:

a sensor configured to detect an image of the particle; and

a plurality of corrective optical elements, each of which may by selectably disposed between the vessel and the sensor and configured to compensate for distortion of the time-series data caused by curvature of the vessel.

14. The apparatus of claim 1, wherein the imager comprises:

a first sensor configured to detect a first image of at least part of the fluid at a first resolution and a first imaging speed; and

a second sensor configured to detect a first image of at least part of the fluid at a second resolution finer than the first resolution and a second imaging speed slower than the first imaging speed.

15. The apparatus of claim 1, wherein the imager comprises:

a first sensor configured to detect a first image of at least part of the fluid at a first magnification; and

a second sensor configured to detect a second image of at least part of fluid at a second magnification greater than the first magnification.

16. The apparatus of claim 1, wherein the imager comprises a plurality of sensors disposed about a circumference of the vessel.

17. The apparatus of claim 1, wherein the imager comprises a polarizer configured to polarize light that is transmitted, scattered, or reflected by the particle.

~~18.~~7. The apparatus of claim 1 or 2, wherein the processor is further configured to subtract static features from the time-series data or the reversed time-series data.

~~19.~~8. The apparatus of claim 1 or 2, wherein the processor is further configured to threshold the time-series data or reversed time-series data.

~~20.~~9. The apparatus of claim 1 or 2, wherein the processor is further configured to estimate the trajectory of the particle by:

(1) locating a first value representing a center of mass of the particle in a first frame of the reversed time-series data;

(2) searching for a second value representing the center of mass of the particle in a predetermined portion of a second frame of the reversed time-series data based on the location of the first value; and

(3) determining a displacement of the particle based on a difference between coordinates associated with the first and second values.

~~21.~~10. The apparatus of claim 9~~19~~, wherein the processor is further configured to determine the predetermined portion of the second frame based on a particle velocity or particle acceleration derived from the first value.

~~22.~~11. The apparatus of claim 1 or 2, wherein the processor is further configured to identify the particle based at least in part on a velocity vector, speed, or coordinate of the particle or combinations thereof.

~~23.~~12. The apparatus of claim 1 or 2, wherein the processor is further configured to identify the particle based at least in part on a change in reflectivity of the particle as a function of time.

~~24.~~13. The apparatus of claim 1 or 2, wherein the processor is further configured to determine a size, elongation, circularity, brightness, color, reflectance, absorbance, fluorescence, contrast or shape of the particle, or a combination of any of these, based on the time-series data.

~~25.~~14. The apparatus of claim ~~24~~13, wherein the processor is further configured to identify the particle based at least in part on the size, elongation, circularity, brightness, or shape of the particle, or combinations thereof.

~~26.~~15. The apparatus of claim 1 or 2, wherein the processor is further configured to:

count values representing one or more particles in the fluid in at least two frames of the time-series data to produce first and second counts, respectively, of the one or more particles; and

determine that the particle has occluded or collided with another particle based on a difference between the first and second counts.

~~27.~~16. The apparatus of claim 1 or 2, wherein the processor is further configured to:

detect a meniscus of the fluid in the vessel based on the time-series data or reversed time-series data;

determine a time that the meniscus is in a stable position; and

select a starting point of the reversed time-series data for estimating the trajectory based on the time that the meniscus is in a stable position.

~~28.~~17. The apparatus of claim ~~27~~16, wherein the processor is further configured to:

determine when a speed of the particle equals a predetermined speed based on the time-series data or reversed time-series data; and

select a stopping point of the reversed time-series data for estimating the trajectory based on the speed of the particle relative to the predetermined speed.

~~29.~~18. The apparatus of claim ~~27~~16, wherein the particle is suspended in a vortex in the fluid, and wherein the processor is further configured to:

detect a collapse of the vortex based on the time-series data or reversed time-series data; and

select a stopping point of the reversed time-series data for estimating the trajectory based on the collapse of the vortex.

~~30.~~19. The apparatus of claim 1 or 2, wherein the processor is further configured to:

select a starting point of the reversed time-series data for estimating the trajectory based on the vessel and on an agitation of the vessel; and

select a stopping point of the reversed time-series data for estimating the trajectory based on the vessel and on an agitation of the vessel.

~~31.~~20. The apparatus of claim 1 or 2, further comprising:

a radiation source configured to irradiate at least a portion of the fluid.

~~32.~~21. The apparatus of claim ~~31~~20, wherein the radiation source is disposed to irradiate the particle at an angle with respect to a plane defined by revolving the imager about a longitudinal axis of the vessel.

~~33.~~22. The apparatus of claim ~~31~~20, wherein the radiation source is further configured to irradiate the particle in synchronization with acquisition of the time-series data by the imager.

~~34.~~23. The apparatus of claim ~~31~~20, wherein the radiation source is further configured to irradiate the particle at an excitation wavelength that causes the particle to fluoresce at a fluorescence wavelength, and

wherein the imager is further configured to detect radiation at the fluorescence wavelength.

~~35.~~24. The apparatus of claim 1 or 2, further comprising an agitator configured to suspend the particle in the fluid.

~~36.~~25. The apparatus of claim ~~35~~24, wherein the agitator is further configured to spin the vessel about its longitudinal axis.

~~37.~~26. The apparatus of claim ~~35~~24, wherein the agitator is further configured to rotate the vessel about an axis perpendicular to its longitudinal axis.

~~38.~~27. The apparatus of claim ~~35~~24, wherein the agitator is further configured to invert the vessel.

~~39.~~28. The apparatus of claim ~~35~~24, wherein the agitator is further configured to vibrate or shake the vessel.

~~40.~~29. A method of nondestructive detection of an undissolved particle in a vessel that is at least partially filled with a fluid, the method comprising:

(a) imaging the particle at different points in time to provide time series data by:

sensing the particle with a first detector having a first resolution and a first imaging speed; and

sensing the particle with a second detector having a second resolution finer than the first resolution and a second imaging speed slower than the first imaging speed;

(~~a~~b) reversing a time ordering of the time-series data representing a trajectory of the particle in the fluid to form reversed time-series data;

(~~b~~c) estimating the trajectory of the particle from the reversed time-series data; and

(~~c~~d) detecting or identifying the particle based on the trajectory.

~~41.~~30. The method of claim ~~40~~29, wherein the particle has a minimum width of about 1 µm to about 400 µm.

~~42.~~31. The method of claim ~~40~~29, wherein the particle has a minimum width of about 75 to about 150 µm.

~~43.~~32. The method of claim ~~40~~29, wherein the particle has a minimum width of about 1 µm or greater.

~~44.~~33. The method of claim ~~40~~29, wherein the particle includes a protein aggregate.

~~45.~~34. The method of claim ~~40~~29, wherein estimating the trajectory of the particle comprises subtracting background data from the time-series data or the reversed time-series data.

~~46.~~35. The method of claim ~~40~~29, wherein estimating the trajectory of the particle comprises thresholding time-series data or reversed time-series data.

~~47.~~36. The method of claim ~~40~~29, wherein estimating the trajectory of the particle comprises:

(1) locating a first value representing a center of mass of the particle in a first frame of the reversed time-series data;

(2) searching for a second value representing the center of mass of the particle in a predetermined portion of a second frame of the reversed time-series data based on the location of the first value; and

(3) determining a displacement of the particle based on a difference between coordinates associated with the first and second values.

~~48.~~37. The method of claim ~~47~~36, further comprising determining the predetermined portion of the second frame based at least in part on a particle velocity or particle acceleration derived at least in part from the first value.

~~49.~~38. The method of claim ~~40~~29, wherein identifying the particle comprises classifying the particle based at least in part on a velocity vector, speed, status, or coordinate of the particle or combinations thereof.

~~50.~~39. The method of claim ~~40~~29, wherein identifying the particle comprises classifying the particle based at least in part on a change in reflectivity of the particle as a function of time.

~~51.~~40. The method of claim ~~40~~29, further comprising:

determining a size, elongation, circularity, brightness, shape, color, fluorescence, contrast, reflectance, or absorbance of the particle, or a combination of any of these.

~~52.~~41. The method of claim ~~51~~40, wherein identifying the particle comprises classifying the particle based at least in part on the size, elongation, brightness, or shape of the particle.

~~53.~~42. The method of claim ~~40~~29, further comprising:

counting values representing one or more particles in the fluid in at least two frames of the time-series data to produce first and second counts, respectively, of the one or more particles; and

determining that the particle has occluded or collided with another particle in the fluid based on a difference between the first and second counts.

~~54.~~43. The method of claim ~~40~~29, further comprising:

detecting a meniscus of the fluid in the vessel based on the time-series data or the reversed time-series data;

determining that the meniscus is in a stable position; and

selecting a starting point of the reversed time-series data for estimating the trajectory based on a stability of the meniscus.

~~55.~~44. The method of claim ~~40~~29, further comprising:

determining when a speed of the particle equals a predetermined speed based on the time-series data or the reversed time-series data; and

selecting a stopping point of the reversed time-series data for estimating the trajectory based on the speed of the particle relative to the predetermined speed.

~~56.~~45. The method of claim ~~40~~29, wherein the particle is suspended in a vortex in the fluid, and further comprising:

detecting a collapse of the vortex based on the time-series data or the reversed time-series data; and

selecting a stopping point of the reversed time-series data for estimating the trajectory based on the collapse of the vortex.

~~57.~~46. The method of claim ~~40~~29, further comprising:

selecting a starting point of the reversed time-series data for estimating the trajectory based on the vessel and on an agitation of the vessel; and

selecting a stopping point of the reversed time-series data for estimating the trajectory based on the vessel and on an agitation of the vessel.

~~58.~~47. The method of claim ~~40~~29, further comprising causing the particle to become suspended in the fluid.

~~59.~~48. The method of claim ~~58~~47, wherein causing the particle to become suspended comprises spinning the vessel about its longitudinal axis.

~~60.~~49. The method of claim ~~58~~47, wherein causing the particle to become suspended comprises rotating the vessel about an axis perpendicular to its longitudinal axis.

~~61.~~50. The method of claim ~~58~~47, wherein causing the particle to become suspended comprises inverting the vessel.

~~62.~~51. The method of claim ~~58~~47, wherein causing the particle to become suspended comprises shaking or vibrating the vessel.

~~63. The method of claim 40, further comprising irradiating the particle.~~

~~64. The method of claim 63, wherein irradiating the particle comprises triggering the irradiating in synchronization with acquisition of the time-series data.~~

65. The method of claim 63, further comprising wherein imaging the particle comprises sensing radiation with a sensor, and

wherein irradiating the particle comprises irradiating the particle at an angle with respect to a plane defined by revolving the sensor about a longitudinal axis of the vessel.

66. The method of claim 40, further comprising imaging the particle at different points in time to provide the time-series data.

67. The method of claim 66, wherein imaging the particle comprises projecting an image of the particle onto a sensor with a telecentric lens.

68. The method of claim 67, further comprising cooling the sensor.

69. The method of claim 67, wherein imaging the particle comprises projecting an image of the particle onto a sensor with the telecentric lens and a corrective optical element, wherein the corrective optical element substantially corrects for distortion the image caused by curvature of the vessel.

70. The method of claim 67, wherein imaging the particle comprises:

providing a plurality of corrective optical elements, each of which may by selectably disposed between the vessel and the sensor;

selecting one of the plurality of corrective optical elements; and

projecting an image of the particle onto a sensor with the telecentric lens and the selected one of the corrective optical element, wherein optical element substantially corrects for magnification distortion of the time-series data caused by curvature of the vessel.

71. The method of claim 66, wherein imaging the particle comprises:

sensing the particle with a first detector having a first resolution and a first imaging speed; and

sensing the particle with a second detector having a second resolution finer than the first resolution and a second imaging speed slower than the first imaging speed.

72. The method of claim 66, further comprising:

causing the particle to fluoresce at a fluorescence wavelength, and

~~wherein imaging the particle comprises sensing light at the fluorescence wavelength.~~

~~73. The method of claim 66, further comprising polarizing light that is transmitted, scattered, or reflected by the particle.~~

~~74. A computer program product for nondestructive detection of an undissolved particle in a vessel that is at least partially filled with a fluid, the computer program product comprising nonvolatile, machine-readable instructions, which, when executed by a processor, cause the processor to:~~

~~(a) reverse a time ordering of time-series data representing a trajectory of the particle in the fluid to form reversed time-series data;~~

~~(b) estimate the trajectory of the particle from the reversed time-series data; and~~

~~(c) detect or identifying the particle based on the trajectory.~~

~~75. An apparatus for nondestructive detection of one or more transparent or reflective objects in a vessel that is at least partially filled with a fluid, the apparatus comprising:~~

~~(a) an imager configured to acquire data that represent light reflected from a plurality of spatial locations in the vessel as a function of time;~~

~~(b) a memory operably coupled to the imager and configured to store the data; and~~

~~(c) a processor operably coupled to the memory and configured to detect the objects based on the data by:~~

~~(i) identifying a respective maximum amount of reflected light for each location in the plurality of locations, and~~

~~(ii) determining a presence or absence of the objects in the vessel based on the number of spatial locations whose respective maximum amount of reflected light exceeds a predetermined value.~~

~~76. The apparatus of claim 75, wherein the vessel has a bottom and further comprising:~~

~~a light source configured to illuminate the bottom of the vessel.~~

77. The apparatus of claim 75, wherein the vessel contains a protein aggregate and wherein the processor is further configured to distinguish the objects from the protein aggregate based on the data.

78. The apparatus of claim 75, wherein the processor is further configured to estimate at least one of an average size of the objects, a size distribution of the objects, and a number of the objects.

79. The apparatus of claim 75, wherein the processor is further configured to distinguish the object from other types of particles based on a variation in the amount of reflected light as a function of time.

80. The apparatus of claim 79, wherein the processor is further configured to identify at least one other type of particle in the vessel using the data and additional data representing light transmitted through the vessel.

81. The apparatus of claim 75, wherein the objects comprise glass lamellae.

82. A method of nondestructive detection of transparent or reflective objects in a vessel that is at least partially filled with a fluid, the method comprising:

(a) identifying a respective maximum amount of reflected light for each location in a plurality of locations in the vessel based on data representing light reflected from the plurality of spatial locations as a function of time; and

(b) determining a presence or absence of the objects in the vessel based on the number of spatial locations whose respective maximum amount of reflected light exceeds a predetermined value.

83. The method of claim 82, wherein the vessel has a bottom and further comprising:

illuminating the bottom of the vessel; and

acquiring the data representing light reflected from the plurality of spatial locations.

84. The method of claim 82, wherein the vessel contains a protein aggregate and further comprising:

distinguishing the objects from the protein aggregate on the basis of the data.

~~85. The method of claim 82, further comprising:~~

~~estimating at least one of an average size of the objects, a size distribution of the objects, and a number of the objects.~~

~~86. The method of claim 82, further comprising:~~

~~distinguishing the objects from another type of particle based on a variation in the amount of reflected light as a function of time.~~

~~87. The method of claim 82, further comprising:~~

~~identifying at least one other type of particle in the vessel using the data and additional data representing light transmitted through the vessel.~~

~~88. The method of claim 82, wherein the objects comprise glass lamellae.~~

~~89. A computer program product for nondestructive detection of transparent or reflective objects in a vessel that is at least partially filled with a fluid, the computer program product comprising nonvolatile, machine-readable instructions, which, when executed by a processor, cause the processor to:~~

~~(a) identify a respective maximum amount of reflected light for each location in a plurality of locations in the vessel based on data representing light reflected from the plurality of spatial locations as a function of time; and~~

~~(b) determine a presence or absence of the objects in the vessel based on the number of spatial locations whose respective maximum amount of reflected light exceeds a predetermined value.~~

~~90.~~52. A method of nondestructive counting and sizing of undissolved particles in a vessel that is at least partially filled with a fluid, the method comprising:

(a) receiving at least one image of the particles in the vessel obtained under specified imaging conditions;

(b) based on the at least one image, detecting the particles and determining information indicative of the apparent size of the detected particles in the image;

(c) determining apparent particle size population information indicative of an apparent particle size distribution of the detected particles; and

(d) determining actual particle size population information indicative of the actual particle size distribution of the detected particles based on

(i) the apparent particle size population information; and

(ii) calibration population information indicative of the apparent size distribution of one or more sets of standard sized particles imaged under conditions corresponding to the specified imaging conditions.

~~91.~~53. The method of claim ~~90~~52, wherein step (d) comprises:

fitting a superposition of apparent size distributions for a plurality of the sets of standard sized particles to the apparent particle size population of the detected particles.

~~92.~~54. The method of claim ~~91~~53, wherein the plurality of sets of standard sized particles comprises at least four sets each having a different respective standard size.

~~93.~~55. The method of claim ~~92~~54, wherein the respective size of each one of the at least four sets of standard sized particles differs by at least 1 μm from the respective size of each of the other ones of the at least four sets of standard sized particles.

~~94.~~56. The method of claim ~~91~~53, wherein the step of fitting the superposition of apparent size distributions for the plurality of sets of standard sized particles conditions to the apparent particle size population of the detected particles comprises:

minimizing a difference between the superposition and the apparent particle size population of the detected particles by adjusting the weighting of the apparent size distributions for the plurality of sets of standard sized particles.

~~95.~~57. The method of claim ~~90~~52, comprising, prior to (c) and (d), preprocessing the at least one image to select a first set of particles for counting based on the apparent size of the particles, wherein (c) and (d) is applied only to the first set of particles.

~~96.~~58. The method of claim ~~95~~57, wherein the particles in the first set of particles are selected based on an apparent size threshold.

~~97.~~59. The method of claim ~~96~~58, wherein the at least one image comprises a time-series of images, and comprising:

detecting or counting particles of a second set of particles different from the first

by determining trajectories of the second set of particles based on the time-series of images.

~~98.~~60. An apparatus for counting and sizing undissolved particles in a vessel that is at least partially filled with a fluid, the apparatus comprising at least one processor configured to:

(a) receive at least one image of the particles in the vessel obtained under specified imaging conditions;

(b) based on the at least one image, detect the particles and determine information indicative of the apparent size of the detected particles in the image;

(c) determine apparent particle size population information indicative of an apparent particle size distribution of the detected particles; and

(d) determine actual particle size population information indicative of the actual particle size distribution of the detected particles based on

(i) the apparent particle size population information and

(ii) calibration population information indicative of the apparent size distribution of one or more sets of standard sized particles imaged under conditions corresponding to the specified imaging conditions.

~~99.~~61. The apparatus of claim ~~98~~60, wherein the processor is configured to:

fit a superposition of apparent size distributions for a plurality of sets of standard sized particles imaged to the apparent particle size population of the detected particles.

~~100.~~62.The apparatus of claim ~~99~~61, wherein the plurality of sets of standard sized particles comprises at least four sets each having a different respective standard size.

~~101.~~63.The apparatus of claim ~~100~~62, wherein the respective size of each one of the at least four sets of standard sized particles differs by at least 1 μm from the respective size of each of the other ones of the at least four sets of standard sized particles.

~~102.~~64.The apparatus of claim ~~98~~60, wherein the processor is configured to fit the superposition of apparent size distributions for the plurality of sets of standard sized particles to the apparent particle size population of the detected particles by:

minimizing a difference between the superposition and the apparent particle size

population of the detected particles by adjusting the weighting of the apparent size distributions for the plurality of sets of standard sized particles.

~~103.~~65.The apparatus of claim ~~98~~60, the processor is configured to preprocess the at least one image to select a first set of particles for counting based on the apparent size of the particles, wherein (c) and (d) is applied only to the first set of particles.

~~104.~~66.The apparatus of claim ~~103~~65, wherein the particles in the first set of particles are selected based on an apparent size threshold.

~~105.~~67.The apparatus of claim ~~104~~66, wherein the at least one image comprises a time-series of images, and wherein the processor is configured to detect or count particles of a second set of particles different from the first by determining trajectories of the second set of particles based on the time-series of images.

~~106.~~68.A computer program product for nondestructive counting and sizing of undissolved particles in a vessel that is at least partially filled with a fluid, the computer program product comprising nonvolatile, machine-readable instructions, which, when executed by a processor, cause the processor to

(a) receive~~ing~~ at least one image of the particles in the vessel obtained under specified imaging conditions;

(b) based on the at least one image, detect~~ing~~ the particles and determine~~ing~~ information indicative of the apparent size of the detected particles in the image

(c) determine~~ing~~ apparent particle size population information indicative of an apparent particle size distribution of the detected particles; and

(d) determining actual particle size population information indicative of the actual particle size distribution of the detected particles based on

(i) the apparent particle size population information; and

(ii) calibration population information indicative of the apparent size distribution of one or more sets of standard sized particles imaged under conditions corresponding to the specified imaging conditions.

~~107.~~69.An apparatus for nondestructive detection of an undissolved particle in a vessel that is at least partially filled with a fluid, the apparatus comprising:

(a) at least two imagers positioned to image the particle from different perspectives, each imager configured to acquire one or more two dimensional images of the particle in the fluid;

(b) a memory operably coupled to the imager and configured to store the time-series; and

(c) a processor operably coupled to the memory and configured to detect the particle by:

(i) combining the two dimensional images from the at least ~~three~~ two imagers to determine three dimensional data indicative of the position of the particle in the vessel; and

(ii) detecting the particle based at least in part on the three dimensional data.

~~108.~~70. The apparatus of claim ~~107~~69, wherein the processor is further configured to:

identify candidate particles based on the three dimensional data; and

determine size or shape information for the particle based on two-dimensional image data from at least one of the imagers.

~~109.~~71. The apparatus of claim ~~108~~70, wherein the processor is further configured to:

correct the determined size or shape information for the particle based on the three dimensional data and data indicative of position dependent optical distortion caused by the vessel.

~~110.~~72. The apparatus of claim ~~107~~69, wherein the three dimensional trajectory data comprises at least one blind spot region corresponding to a region of the vessel not imaged by at least three of the imagers, and wherein the processor is configured to:

determine blind spot trajectory information indicative of the path of the particle in the blind spot region, based at least in part on time-series of two dimensional images of the particle from the imager located closest to the blind spot region.

~~111.~~73. The apparatus of claim ~~107~~69, wherein the at least two imagers comprise at least three imagers.

~~112.~~74. The apparatus of claim ~~107~~69, wherein each of the at least two imagers comprises:

a sensor configured to detect an image of the particle; and

a corrective optical element disposed between the particle and the sensor and configured to compensate for distortion of the time-series data caused by curvature of the vessel.

~~113.~~75.The apparatus of claim ~~112~~74, wherein each of the imagers further comprises a telecentric lens disposed between the sensor and the vessel, and wherein the corrective optical element substantially corrects for magnification distortion of the time-series data caused by curvature of the vessel.

~~114.~~76.A~~n~~ method for nondestructive detection of an undissolved particle in a vessel that is at least partially filled with a fluid, the method comprising:

(a) using at least two imagers to image the particle from different perspectives to each acquire a respective one or more two dimensional images of the particle in the fluid;

(b) combining the two dimensional images from the at least two imagers to determine three dimensional data indicative of the position of the particle in the vessel; and

(c) detecting the particle based at least in part on the three dimensional data.

~~115.~~77.The method of claim ~~114~~76, further comprising:

identifying candidate particles based on the three dimensional data; and

determining size or shape information for the particle based on the two-dimensional image from at least one of the imagers.

~~116.~~78.The method of claim ~~115~~77, comprising:

correcting the determined size or shape information for the particle based on the three dimensional data and data indicative of position dependent optical distortion caused by the vessel.

~~117.~~79.The method of claim ~~114~~76, wherein the three dimensional trajectory data comprises at least one blind spot region corresponding to a region of the vessel not imaged by at least three imagers, and comprising:

determining blind spot trajectory information indicative of the path of the particle in the blind spot region, based at least in part on time-series of two dimensional images of the particle from the imager located closest to the blind spot region.

~~118.~~80.The method of claim ~~114~~76, wherein the at least two imagers comprises at least three imagers.

~~119.~~81.The method of claim ~~114~~76, wherein each of the at least two imagers comprises:

a sensor configured to detect an image of the particle; and

a corrective optical element disposed between the particle and the sensor and configured to compensate for distortion of the time-series data caused by curvature of the vessel.

~~120.~~82.The method of claim ~~119~~81, wherein the imager further comprises a telecentric lens disposed between the sensor and the vessel, and wherein the corrective optical element substantially corrects for magnification distortion of the time-series data caused by curvature of the vessel.

~~121.~~83.A method for nondestructive detection of an undissolved particle in a vessel that is at least partially filled with a fluid, the method comprising:

(a) using at least one imager to image the particle;

(b) processing the image to determine position data indicative of the position of the particle in the vessel;

(c) detecting the particle based at least in part on the position data, wherein detecting the particle based at least in part on position data comprises identifying the presence of the particle in a sub-region of the vessel;

(d) using a sensor to determine a characteristic of the particle when the particle is located in the sub-region of the vessel,

(e) generating particle characteristic data indicative of the determined characteristic; and

(f) associating the particle characteristic data with data identifying the particle;~~.~~

~~122. The method of claim 121,~~ wherein:

the at least one imager comprises at least two imagers positioned to image the particle from different perspectives to each acquire a respective one or more two dimensional images of the particle in the fluid,

processing the image to determine position data comprises combining the two dimensional images from the at least two imagers to determine three dimensional data

indicative of the position of the particle in the vessel; and

detecting the particle comprises detecting the particle based at least in part on the three dimensional data.

~~123.~~84.The method of claim ~~122~~83, wherein the characteristic of the particle comprises a spectral characteristic.

~~124.~~85.The method of claim ~~123~~84, wherein the sensor comprises a spectrometer device positioned to sense spectral characteristics of light incident from the sub-region of the vessel.

~~125.~~86.The method of claim ~~124~~85, wherein the sub-~~-~~region comprises a substantially planar layer of fluid in the vessel.

~~126.~~87.The method of claim ~~125~~86, wherein the sensor comprises a telecentric imager positioned to image the sub-region of the vessel onto the spectrometer.

~~127.~~88.The method of claim ~~124~~84, wherein the spectral characteristic comprises a color, an absorption spectrum, or a transmission spectrum or a combination of any of these.

~~128.~~89.An apparatus for nondestructive detection of an undissolved particle in a vessel that is at least partially filled with a fluid, the apparatus comprising:

(a) at least one imager positioned to image the particle;

(b) at least one sensor configured to determine a characteristic of the particle when the particle is located in the sub-region of the vessel;

(c) at least one processer operably coupled to the each at least one imager and the sensor and configured to:

process the image to determine position data indicative of the position of the particle in the vessel;

detect the particle based at least in part on the position data and identify the presence of the particle in a sub-region of the vessel;

use a signal from the sensor to determine a characteristic of the particle when the particle is located in the sub-region of the vessel~~,~~;

generate particle characteristic data indicative of the determined characteristic; and

associate the particle characteristic data with data identifying the particle~~.~~;

~~129.~~ ~~The apparatus of claim 128,~~ wherein:

the at least one imager comprises at least two imagers positioned to image the particle from different perspectives to each acquire a respective one or more two dimensional images of the particle in the fluid,

the processor is configured to combine the two dimensional images from the at least two imagers to determine three dimensional data indicative of the position of the particle in the vessel; and

the processor is configured to detect the particle based at least in part on the three dimensional data.

~~130.~~90.The apparatus of claim ~~129~~89, wherein the characteristic of the particle comprises a spectral characteristic.

~~131.~~91.The apparatus of claim ~~130~~90, wherein the sensor comprises a spectrometer device positioned to sense spectral characteristics of light incident from the sub-region of the vessel.

~~132.~~92.The apparatus of claim ~~131~~91, wherein the sub-region comprises a substantially planar layer of fluid in the vessel.

~~133.~~93.The apparatus of claim ~~132~~91, wherein the sensor comprises a telecentric imager positioned to image the sub-region of the vessel onto the spectrometer.

~~134.~~94.The apparatus of claim ~~131~~91, wherein the spectral characteristic comprises a color, an absorption spectrum, or a transmission spectrum or a combination of any of these.

~~135. An apparatus for nondestructive detection of an undissolved particle in a vessel that is at least partially filled with a fluid, wherein the vessel comprises a transparent tubular vessel wall disposed about a longitudinal axis, the apparatus comprising:~~

~~an imager configured to acquire one or more images of the particle in the fluid, the imager comprising a at least one imaging optical element positioned to image the particle onto the sensor;~~

~~an illumination source positioned at least partially within a plane passing through the vessel and substantially orthogonal to the longitudinal axis of the vessel, the~~

illumination source arranged to substantially eliminate the presence of light rays emitted from the source that reflect or refract from a surface of the vessel wall and are imaged by the at least one optical element onto the sensor.

136. The apparatus of claim 135, wherein the illumination source is located in a region outside of the vessel that would be substantially free of any back-propagating rays extending from the sensor, through the at least one imaging optical element and subsequently through the vessel.

137. The apparatus of claim 136, wherein the at least one optical element comprises a telecentric lens.

138. The apparatus of claim 137, wherein the transparent tubular vessel wall comprises a cylindrical wall, and wherein the longitudinal axis corresponds to an axis of symmetry of the cylindrical wall.

139. The apparatus of claim 138, wherein an optic axis of the imager extends through the vessel substantially orthogonal to and intersecting with the longitudinal axis of the vessel.

140. The apparatus of claim 137, wherein the imager is configured to acquire time-series data representing a trajectory of the particle in the fluid , the apparatus further comprising:

(a) a memory operably coupled to the imager and configured to store the time-series data; and

(b) a processor operably coupled to the memory and configured to detect the particle by:

(i) reversing a time ordering of the time-series data to form reversed time-series data;

(ii) estimating the trajectory of the particle from the reversed time-series data; and

(iii) determining a presence or type of the particle based on the trajectory.

141. A method for nondestructive detection of an undissolved particle in a vessel that is at least partially filled with a fluid, wherein the vessel comprises a

~~transparent tubular vessel wall disposed about a longitudinal axis, the method comprising:~~

~~using an imager to acquire one or more images of the particle in the fluid, the imager comprising at least one imaging optical element positioned to image the particle onto the sensor; and~~

~~illuminating the vessel with an illumination source positioned at least partially within a plane passing through the vessel and substantially orthogonal to the longitudinal axis of the vessel, the illumination source arranged to substantially eliminate the presence of light rays emitted from the source that reflect or refract from a surface of the vessel wall and are imaged by the at least one optical element onto the sensor.~~

~~142. The method of claim 141, wherein the illumination source is located in a region outside of the vessel that would be substantially free of any back-propagating rays extending from the sensor, through the at least one optical element and subsequently through the vessel.~~

~~143. The method of claim 142, wherein the at least one optical element comprises a telecentric lens.~~

~~144. The method of claim 143, wherein the transparent tubular vessel wall comprises a cylindrical wall, and wherein the longitudinal axis corresponds to an axis of symmetry of the cylindrical wall.~~

~~145. The method of claim 144, wherein an optic axis of the imager extends through the vessel substantially orthogonal to and intersecting with the longitudinal axis of the vessel.~~

~~146. The method of claim 145, comprising:~~

~~using the imager to acquire time-series data representing a trajectory of the particle in the fluid; and~~

~~detecting the particle by:~~

~~(i) reversing a time ordering of the time-series data to form reversed time-series data;~~

~~(ii) estimating the trajectory of the particle from the reversed time-series data; and~~

~~(iii) determining a presence or type of the particle based on the trajectory.~~