Part 2
White Light Velocity Interferometer, continued

This is a continuation of US Patent 5,642,194. Only the claims section is different.

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The invention is a technique that allows the use of unlimited bandwidth and extended illumination sources to measure small Doppler shifts of targets external to the apparatus. Monochromatic and point-like sources can also be used, thus creating complete flexibility for the illumination source. Although denoted white light velocimetry, the principle can be applied to any wave phenomenon, such as sound, microwaves and light. For the first time, powerful, compact or inexpensive broadband and extended sources can be used for velocity interferometry, including flash and arc lamps, light from detonations, pulsed lasers, chirped frequency lasers, and lasers operating simultaneously in several wavelengths. Superimposing interferometers are created which produce delays independent of ray angle for rays leaving a given pixel of an object, which can be imaged through the interferometer.

I. CLAIMS

(Submitted, not official version)

1. A method of imprinting at least one coherent echo on a beam, comprising:

creating an apparent mirror by real imaging or virtual imaging of an end mirror, wherein the imaged surface of said end mirror defines the location of said apparent mirror, wherein the imaged center of curvature of said end mirror defines the center of curvature of said apparent mirror;

providing a second mirror optimally having the same curvature as said apparent mirror; and

superimposing the location of said second mirror with the location of said apparent mirror in the reflection of a beamsplitting surface.

2. The method of claim 1, wherein said apparent mirror can be slightly tilted from perfect overlap in order to create a delay time which varies with position across the plane of said apparent mirror, wherein said beam can be any wave kind which travels in 2 or 3 dimensions.

3. The method of claim 2, wherein said wave kind comprises electromagnetic waves selected from a group consisting of microwaves, visible light, infrared light, ultraviolet light and x-rays.

4. The method of claim 2, wherein said wave kind comprises sound waves.

5. The method of claim 1, wherein said beam is uncollimated, wherein said beam comprises a range of ray angles significant enough to prevent a coherent delay if said beam were to propagate in free space over a distance comparable to the distance between said apparent mirror and said end mirror.

6. The method of claim 1, wherein said real imaging is accomplished using at least one elements selected from a group consisting of lenses, curved mirrors, plane mirrors, distributed mirrors and waveguides.

7. The method of claim 6, wherein said real imaging is accomplished using at least one transmissive lens and said end mirror.

8. The method of claim 7, wherein said end mirror comprises a curved mirror.

9. The method of claim 6, wherein said end mirror comprises a plane mirror in combination with a lens which together effectively act as a curved mirror.

10. The method of claim 6, wherein said real imaging is accomplished by a transmissive lens, at least one center curved mirror and said end mirror.

11. The method of claim 10, wherein said end mirror comprises a curved mirror.

12. The method of claim 10, wherein said end mirror comprises a plane mirror in combination with a lens which together effectively act as a curved mirror.

13. The method of claim 1, wherein the optics forming said apparent mirror are achromatic so that the location of said apparent mirror is approximately constant over a significant range of wavelengths.

14. The method of claim 1, wherein at least one of the elements forming said apparent mirror is a distributed mirror comprising an effective reflective surface depth that is a function of wavelength.

15. The method of claim 14, wherein said effective reflective surface depth wavelength dependence compensates for chromatic dispersion of other elements forming said apparent mirror so that the net chromatic abberation of said apparent mirror is reduced.

16. The method of claim 1, wherein said virtual imaging is accomplished using lenses and a curved end mirror.

17. A method of imprinting an infinite series of diminishing amplitude coherent echos on a beam, comprising:

creating an apparent mirror by real or virtual imaging of a first end mirror, which may be partially transmitting;

providing a second end mirror having the same curvature and curvature polarity as said apparent mirror, wherein said second end mirror may be partially transparent;

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superimposing said second end mirror with said apparent mirror so that a recirculating path is created having a magnification of positive unity for a roundtrip along the optic axis, wherein said roundtrip is from said first end mirror to said second end mirror then back to said first end mirror;

introducing said beam to said recirculating path by partial transmission through a partially reflecting surface; and

extracting a portion of said beam from said recirculating path through a partially transmitting surface, wherein the roundtrip travel time along said recirculating path determines the interferometer delay time, wherein said portion comprises an infinite series of diminishing amplitude coherent echos.

18. The method of claim 17, wherein said beam is uncollimated, wherein said beam comprises a range of ray angles significant enough to prevent a coherent delay if said beam were to propagate in free space over a distance comparable to the distance between said apparent mirror and said first end mirror.

19. The method of claim 17, wherein said real imaging is accomplished using at least one element selected from a group consisting of lenses, curved mirrors, plane mirrors, distributed mirrors and waveguides.

20. The method of claim 19, wherein said real imaging is accomplished by at least one lens and said end mirror.

21. The method of claim 20, wherein said end mirror comprises a curved mirror.

22. The method of claim 20, wherein said end mirror comprises a plane mirror in combination with a lens which together effectively act as a curved mirror.

23. The method of claim 20, wherein said real imaging is accomplished using at least one curved mirror and and said end mirror.

24. The method of claim 23, wherein said end mirror comprises a curved mirror.

25. The method of claim 23, wherein said end mirror comprises a plane mirror in combination with a lens which together effectively act as a curved mirror.

26. A method of coherently delaying a beam, comprising;

creating an apparent mirror by real or virtual imaging of an end mirror, wherein the imaged surface of said end mirror defines the location of said apparent mirror, wherein the imaged center of curvature of said end mirror defines the center of curvature of said apparent mirror; and

reflecting said beam off said apparent mirror, wherein the beam is delayed by the interval of round trip travel between said apparent mirror and said end mirror and back to said apparent mirror, wherein the beam can be any wave kind which travels in 2 or 3 dimensions.

27. The method of claim 26, wherein said wave kind is visible light.

28. The method of claim 26, wherein said wave kind comprises electromagnetic waves selected from a group consisting of microwaves, visible light, infrared light, ultraviolet light and x-rays.

29. The method of claim 26, wherein said wave kind comprises sound waves.

30. The method of claim 26, wherein said wave kind comprises matter waves.

31. The method of claim 26, wherein said beam is uncollimated, wherein said beam comprises a range of ray angles significant enough to prevent a coherent delay if said beam were to propagate in free space over a distance comparable to the distance between said apparent mirror and said end mirror.

32. The method of claim 26, wherein said real imaging is accomplished using at least one element selected from a group consisting of lenses, curved mirrors, plane mirrors, distributed mirrors and waveguides.

33. The method of claim 32, wherein said real imaging is accomplished with at least one lens and said end mirror.

34. The method of claim 33, wherein said end mirror comprises a curved mirror.

35. The method of claim 33, wherein said end mirror comprises a plane mirror in combination with a lens which together effectively act as a curved mirror.

36. The method of claim 32, wherein the real imaging is accomplished with a transmissive lens, at least one center curved mirror and said end mirror.

37. The method of claim 36, wherein said end mirror comprises a curved mirror.

38. The method of claim 36, comprises a plane mirror in combination with a lens which together effectively act as a curved mirror.

39. The method of claim 26, wherein the optics forming said apparent mirror are individually or as a group achromatic so that the location of said apparent mirror is approximately constant over a significant range of wavelengths.

40. The method of claim 26, wherein at least one of the elements forming said apparent mirrors comprises a distributed mirror whose effective reflective surface depth is a function of wavelength.

41. The method of claim 40, wherein the wavelength dependence of said effective reflective surface depth compensates for chromatic dispersion of other elements forming said apparent mirror so that the net chromatic abberations of said apparent mirror is reduced.

42. The method of claim 26, wherein said virtual imaging is accomplished by a lens and a curved end mirror.

43. An apparatus for imprinting at least one coherent echo on a beam, comprising:

means for creating an apparent mirror by real imaging or virtual imaging of an end mirror, wherein the imaged surface of said end mirror defines the location of said apparent mirror, wherein the imaged center of curvature of said end mirror defines the center of curvature of said apparent mirror;

providing a second mirror optimally having the same curvature as said apparent mirror; and

superimposing the location of said second mirror with the location of said apparent mirror in the reflection of a beamsplitting surface.

44. The apparatus of claim 43, wherein said wave kind comprises light.

45. The apparatus of claim 43, wherein said wave kind comprises electromagnetic waves selected from a group consisting of microwaves, visible light, infrared light, ultraviolet light and x-rays.

46. The apparatus of claim 43, wherein said wave kind comprises sound waves.

47. The apparatus of claim 43, wherein said beam is uncollimated, which is to say that there is a range of ray angles significant enough to prevent a coherent delay if said beam were to propagate in free space over a distance comparable to the distance between said apparent mirror and said end mirror.

48. The apparatus of claim 43, wherein said real imaging is accomplished using at least one element selected from a group consisting of lenses, curved mirrors, plane mirrors, distributed mirrors and waveguides.

49. The apparatus of claim 48, wherein said real imaging is accomplished by one or more transmissive lenses and said end mirror.

50. The apparatus of claim 49, wherein said end mirror comprises a curved mirror.

51. The apparatus of claim 49, wherein said end mirror comprises a plane mirror in combination with a lens which together effectively act as a curved mirror.

52. The apparatus of claim 48, wherein said real imaging is accomplished by a transmissive lens, at least one center curved mirror and said end mirror.

53. The apparatus of claim 52, wherein said end mirror comprises a curved mirror.

54. The apparatus of claim 52, wherein said end mirror comprises a plane mirror in combination with a lens which together effectively act as a curved mirror.

55. The apparatus of 43, wherein the optics forming said apparent mirror are individually or as a group achromatic so that the location of said apparent mirror is approximately constant over a significant range of wavelengths.

56. The apparatus of 43, wherein at least one of the elements forming said apparent mirror comprises a distributed mirror whose effective reflective surface depth is a function of wavelength.

57. The apparatus of 56, wherein the wavelength dependence of said effective reflective surface depth compensates for chromatic dispersion of other elements forming said apparent mirror so that the net chromatic abberations of said apparent mirror are reduced.

58. The apparatus of claim 43, wherein said virtual imaging is accomplished by one or more lenses and a curved said end mirror.

59. An apparatus for imprinting an infinite series of diminishing amplitude coherent echos on a beam, comprising:

means for creating an apparent mirror by real or virtual imaging of an end mirror, which may be partially transmitting;

a second end mirror having the same curvature and curvature polarity as said apparent mirror, wherein this second end mirror may be partially transparent, wherein said second end mirror is superimposed with said apparent mirror so that a recirculating path is created having a magnification of positive unity for a roundtrip along the optic axis, wherein said roundtrip is from said first end mirror to said second end mirror then back to said first said end mirror;

a partially reflecting/transmitting surface through which said beam can be introduced into said recirculating path;

a partially reflecting/transmitting surface through which a portion of said beam from said recirculating path can be extracted, wherein the interferometer delay time is determined by the roundtrip travel time along said recirculating path.

60. The apparatus of claim 59, wherein said beam is uncollimated, wherein said beam comprises a range of ray angles significant enough to prevent a coherent delay if said beam were to propagate in free space over a distance comparable to distance between said apparent mirror and said first end mirror.

61. The apparatus of claim 59, wherein said real imaging is accomplished using at least one element selected from a group consisting of lenses, curved mirrors, plane mirrors, distributed mirrors and waveguides.

62. The apparatus of claim 61, wherein said real imaging is accomplished by at least one lens and said end mirror.

63. The apparatus of claim 62, wherein said end mirror comprises a curved mirror.

64. The apparatus of claim 62, wherein said end mirror comprises a plane mirror in combination with a lens which together effectively act as a curved mirror.

65. The apparatus of claim 62, wherein said real imaging is accomplished using one or more curved mirrors and said end mirror.

66. The apparatus of claim 65, wherein said end mirror comprises a curved mirror.

67. The apparatus of claim 65, wherein said end mirror comprises a plane mirror in combination with a lens which together effectively act as a curved mirror.

68. An apparatus for coherently delaying a beam, comprising;

an end mirror; and

means for creating an apparent mirror by real or virtual imaging of said end mirror, wherein the imaged surface of said end mirror defines the location of said apparent mirror, wherein the imaged center of curvature of said end mirror defines the center of curvature of said apparent mirror, wherein said beam is reflected off said apparent mirror, wherein the beam is delayed by the interval of round trip travel between said apparent mirror and said end mirror and back to said apparent mirror, wherein the beam can be any wave kind which travels in 2 or 3 dimensions.

69. The apparatus of claim 68, wherein said wave kind comprises visible light.

70. The apparatus of claim 68, wherein said wave kind comprises electromagnetic waves selected from a group consisting of microwaves, visible light, infrared light, ultraviolet light and x-rays.

71. The apparatus of claim 68, wherein said wave kind comprises sound waves.

72. The apparatus of claim 68, wherein said wave kind comprises matter waves.

73. The apparatus of claim 68, wherein said beam is uncollimated, wherein said beam comprises a range of ray angles significant enough to prevent a coherent delay if said beam were to propagate in free space over a distance comparable to the distance between said apparent mirror and said end mirror.

74. The apparatus of claim 68, wherein said real imaging is accomplished using at least one element selected from a group consisting of lenses, curved mirrors, plane mirrors, distributed mirrors and waveguides.

75. The apparatus of claim 74, wherein said real imaging is accomplished by at least one lens and said end mirror.

76. The apparatus of claim 75, wherein said end mirror comprises a curved mirror.

77. The apparatus of claim 75, wherein said end mirror comprises a plane mirror in combination with a lens which together effectively act as a curved mirror.

78. The apparatus of claim 74, wherein the real imaging is accomplished by a transmissive lens, at least one center curved mirror, and said end mirror.

79. The apparatus of claim 78, wherein said end mirror comprises a curved mirror.

80. The apparatus of claim 78, wherein said end mirror comprises a plane mirror in combination with a lens which together effectively act as a curved mirror.

81. The apparatus of 68, wherein the optics forming said apparent mirror are individually or as a group achromatic so that the location of said apparent mirror is approximately constant over a significant range of wavelengths.

82. The apparatus of 68, wherein at least one of the elements forming said apparent mirror comprises a distributed mirror whose effective reflective surface depth is a function of wavelength.

83. The apparatus of 82, wherein the wavelength dependence of said effective reflective surface depth compensates for chromatic dispersion of other elements forming said apparent mirror so that the net chromatic abberations of said apparent mirror is reduced.

84. The apparatus of claim 68, wherein said virtual imaging is accomplished by a lens and a curved said end mirror.

85. The method of claim 2, wherein said wave kind comprises light waves.

86. The method of claim 2, wherein said wave kind comprises matter waves.

87. The apparatus of claim 43, wherein said wave kind comprises matter waves.

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