CLAIMS

1. A spectrometer for detecting an electromagnetic (EM) wave spectrum having one or more wavelength components within a spectral band of interest, comprising:

an entrance aperture;

an exit aperture;

a dispersion and imaging optics configured to create dispersed images of the entrance aperture on a plane of the exit aperture, such that respective images at different wavelength components are offset by different amounts of displacements along a direction of dispersion;

at least one single-pixel detector, each single-pixel detector sensitive to one or more of the wavelength components;

an EM detector;

a first collection optics configured to gather a first EM wave energy incident on the entrance aperture to the EM detector;

a second collection optics configured to gather a second EM wave energy that exits the exit aperture to the at least one single-pixel detector; and

a measurement unit configured to measure the output of the EM detector to determine an intensity distribution of an incident EM wave on the entrance aperture, and further configured to measure the output of the at least one single pixel detector for reconstructing the EM wave spectrum, wherein reconstructing comprises scaling the EM wave spectrum based on the determined intensity distribution of the incident EM wave on the entrance aperture.

2. The spectrometer of claim 1, wherein the entrance aperture comprises at least one entrance slit that is spatially encoded along a direction substantially transverse to the direction of dispersion.

3. The spectrometer of claims 1 or 2, wherein the exit aperture comprises a plurality of exit slits arranged in the direction of dispersion, where each exit slit is spatially encoded along a direction substantially transverse to the direction of dispersion.

4. The spectrometer of any one of claims 1 to 3, wherein an encoding pattern of the at least one entrance slits and/or an encoding pattern of the plurality of exit slits is adjustable and configured to be changed for a number of times.

5. The spectrometer of any one of the preceding claims, wherein the first collection optics is configured to gather the first EM wave energy from the zeroth order diffraction from a dispersion element of the dispersion and imaging optics.

6. The spectrometer of any one of claims 1 to 4, wherein the first collection optics is configured to gather the first EM wave energy from a beam splitter element disposed near the entrance aperture.

7. The spectrometer of any one of the preceding claims, wherein the EM detector comprises a single-pixel detector or an imaging camera,

and/or wherein the spectrometer comprises one or more of a group consisting of:

a bandpass filter for filtering the spectral band of interest from the incident EM wave,

a first field lens configured for pupil matching with a fore optics, for disposal near the entrance aperture,

a second field lens configured for pupil matching with the second collection optics, for disposal near the exit aperture,

and/or wherein the second collection optics comprises a dispersion element to remove the dispersion effects from the dispersion and imaging optics,

and/or wherein adjustable encoding patterns of at least one of the entrance slit and/or the exit slit, respectively, are implemented using microelectromechanical systems (MEMS) technology or using MEMS micromirror arrays,

and/or wherein adjustable encoding patterns of at least one of the entrance slit and/or the exit slit, respectively, are implemented using a movable mask placed in the vicinity of a fixed aperture opening.

8. The spectrometer of any one of the preceding claims, configured as a Raman spectroscopy system.

9. The spectrometer of claim 8, configured for time-gate and/or time-resolved Raman spectroscopy.

10. The spectrometer of claim 8 or 9, wherein the measurement unit is configured for using time correlated single photon counting (TCSPC), wherein 3D histogram data cubes are constructed with the EM detector and the at least the single-pixel detector, and optionally wherein the measurement unit is configured to slice the 3D histogram data cubes at various time delays, each time delay slice representing a complete set of encoded intensity measurements for reconstructing the Raman spectrum at that corresponding time delay and optionally wherein the measurement unit is configured such that time-resolved Raman shift spectra are reconstructed at various time delays.

11. A method of detecting an electromagnetic (EM) wave spectrum having one or more wavelength components within a spectral band of interest, the method comprising the steps of:

creating dispersed images of an entrance aperture on a plane of an exit aperture, such that respective images at different wavelength components are offset by different amounts of displacements along a direction of dispersion;

gathering a first EM wave energy incident on the entrance aperture to an EM detector;

gathering a second EM wave energy that exits the exit aperture to the at least one single-pixel detector;

measuring the output of the EM detector to determine an intensity distribution of an incident EM wave on the entrance aperture; and

measuring the output of the at least one single pixel detector for reconstructing the EM wave spectrum, wherein reconstructing comprises scaling the EM wave spectrum based on the determined intensity distribution of the incident EM wave on the entrance aperture.

12. The method of claim 11, comprising spatially encoding at least one entrance slit of the entrance aperture along a direction substantially transverse to the direction of dispersion.

13. The method of claims 11 or 12, comprising spatially encoding a plurality of exit slits of the exit aperture along a direction substantially transverse to the direction of dispersion.

14. The method of any one of claims 11 to 13, comprising changing an encoding pattern of the at least one entrance slits and/or an encoding pattern of the plurality of exit slits for a number of times.

15. The method of any one of claims 11 to 14, wherein the first EM wave energy is gathered from the zeroth order diffraction from a dispersion element.

16. The method of any one of claims 11 to 14, wherein the first EM wave energy is gathered from a beam splitter element disposed near the entrance aperture.

17. The method of any one of the claims 11 to 16 wherein the EM detector comprises a single-pixel detector or an imaging camera,

and/or wherein the method comprises one or more of a group consisting of:

filtering the spectral band of interest from the incident EM wave,

pupil matching with a fore optics, for disposal near the entrance aperture,

pupil matching with the second collection optics, for disposal near the exit aperture,

removing the dispersion effects from the dispersion and imaging optics,

and/or wherein adjustable encoding patterns of at least one of the entrance slit and/or the exit slit, respectively, are implemented using microelectromechanical systems (MEMS) technology or using MEMS micromirror arrays,

and/or wherein adjustable encoding patterns of at least one of the entrance slit and/or the exit slit, respectively, are implemented using a movable mask placed in the vicinity of a fixed aperture opening.

18. The method of any one of claims 11 to 17, for performing Raman spectroscopy.

19. The method of claim 18, for performing time-gate and/or time-resolved Raman spectroscopy.

20. The method of claims 18 or 19, comprising using time correlated single photon counting (TCSPC), wherein 3D histogram data cubes are constructed with the EM detector and the at least the single-pixel detector, and optionally comprising slicing the 3D histogram data cubes at various time delays, each time delay slice representing a complete set of encoded intensity measurements for reconstructing the Raman spectrum at that corresponding time delay, and optionally comprising reconstructing time-resolved Raman shift spectra at various time delays.