CLAIMS

1. A scintillator material comprising a composition of Formula (III):

$$[(Lu_{1-x}Y_x)_{1-y-z}A_yB_z]_3Al_5O_{12} \quad \text{(III)},$$

wherein:

$0.2 \leq x \leq 0.3$;

$0.004 \leq y \leq 0.015$;

$0.001 \leq z \leq 0.1$;

A is Pr^{3+}; and

B is at least one type of monovalent cation, wherein the monovalent cation is a cation of an element selected from the group consisting of Li, Na, and K.

2. The scintillator material of claim 1, wherein x is 0.25.

3. The scintillator material of claim 1, wherein y is 0.004 or 0.012.

4. The scintillator material of claim 1, wherein B is Li^+.

5. The scintillator material of claim 1, wherein z is 0.002, 0.008, or 0.02.

6. The scintillator material of claim 1, wherein the scintillator material comprises a material selected from the group consisting of $(Lu_{0.75},Y_{0.25})_3Al_5O_{12}$:0.4% Pr^{3+} codoped with 0.2%Li^+, $(Lu_{0.75},Y_{0.25})_3Al_5O_{12}$:0.4% Pr^{3+} codoped with 0.8% Li^+, $(Lu_{0.75},Y_{0.25})_3Al_5O_{12}$:0.4% Pr^{3+} codoped with 2.0% Li^+; $(Lu_{0.75},Y_{0.25})_3Al_5O_{12}$: 1.2% Pr^{3+} codoped with 0.308 at% Na^+, $(Lu_{0.75},Y_{0.25})_3Al_5O_{12}$:1.2% Pr^{3+} codoped with 0.6 at% Li^+, $(Lu_{0.75},Y_{0.25})_3Al_5O_{12}$:1.2% Pr^{3+} codoped with 0.6 at% K^+, $(Lu_{0.75},Y_{0.25})_3Al_5O_{12}$:1.2% Pr^{3+} codoped with 2.4 at% Li^+, and $(Lu_{0.75},Y_{0.25})_3Al_5O_{12}$:1.2% Pr^{3+} codoped with 6 at% Li^+.

7. The scintillator material of claim 6, wherein the material is selected from the group consisting of $(Lu_{0.75},Y_{0.25})_3Al_5O_{12}$:0.4% Pr^{3+} codoped with 0.2% Li^+,

$(Lu_{0.75},Y_{0.25})_3Al_5O_{12}$:0.4% Pr^{3+} codoped with 0.8% Li^+, and $(Lu_{0.75},Y_{0.25})_3Al_5O_{12}$:0.4% Pr^{3+} codoped with 2.0% Li^+.

8. The scintillator material of claim 6, wherein the material is $(Lu_{0.75},Y_{0.25})_3Al_5O_{12}$:0.4% Pr^{3+} codoped with 0.8% Li^+.

9. The scintillator material of claim 1, wherein the scintillator material exhibits one or more of increased light yield, improved energy resolution, and an accelerated fast decay component as compared to the scintillator material where B is absent.

10. The scintillator material of claim 1, wherein the scintillator material is a single crystal material.

11. The scintillator material of claim 1, wherein the scintillator material is a polycrystalline and/or a ceramic material.

12. A radiation detector comprising a photon detector and a scintillation material of claim 1.

13. The radiation detector of claim 12, wherein the detector is a medical diagnostic device, a device for oil exploration, or a device for container or baggage scanning.

14. A method of detecting gamma rays, X-rays, cosmic rays and/or particles having an energy of 1 keV or greater, the method comprising: providing a radiation detector of claim 12; positioning the radiation detector, wherein the positioning comprises placing the radiation detector in a location wherein the scintillation material is in a path of a beam of radiation or a suspected path of a beam of radiation; and detecting light emitted by the scintillation material with the photon detector.

15. A method of preparing a scintillator material of claim 1, wherein the method comprises pulling a single crystal from molten raw materials.

16. The scintillator material of claim 1, wherein the scintillator material has an energy resolution at 662 keV of less than 4.4%.

17. The scintillator material of claim 16, wherein the scintillator material has an energy resolution at 662 keV of 4.3% or less.

18. The scintillator material of claim 16, wherein the scintillator material has an energy resolution at 662 keV of 4.1%.

19. A method of improving energy resolution of a rare earth aluminum garnet scintillator, wherein the rare earth aluminum garnet scintillator is a praseodymium (Pr) doped lutetium yttrium aluminum garnet (LuYAG) scintillator, wherein the method comprises preparing a scintillator material comprising a composition of Formula (III):

$$[(Lu_{1-x}Y_x)_{1-y-z}A_yB_z]_3Al_5O_{12} \qquad \text{(III)},$$

wherein:

$0.2 \leq x \leq 0.3$;

$0.004 \leq y \leq 0.015$;

$0.001 \leq z \leq 0.1$;

A is Pr^{3+}; and

B is at least one type of monovalent cation, wherein the monovalent cation is a cation of an element selected from the group consisting of Li, Na, and K.

20. A scintillator material comprising a composition of Formula (I'):

$$[(RE_{1-x}RE'_x)_{1-y-z}A_yB'_z]_3Al_5O_{12} \qquad \text{(I')},$$

wherein:

$0.2 \leq x \leq 0.3$;

$0.004 \leq y \leq 0.015$;

$0.001 \leq z \leq 0.1$;

RE is Lu;

RE' is Y;

A is Pr^{3+}; and

B' is a monovalent cation of a lithium-6 isotope (i.e., $^{6}Li^{+}$).

21. The scintillator material of claim 20, wherein z is 0.002, 0.008, or 0.02.

22. The scintillator material of claim 20, wherein x is about 0.25.

23. The scintillator material of claim 20, wherein y is 0.004 or 0.012.

24. A radiation detector comprising a photon detector and a scintillator material of claim 20.

25. A method of detecting neutrons, wherein the method comprises: providing a radiation detector of claim 24; positioning the radiation detector, wherein the positioning comprises placing the radiation detector in a location wherein the scintillation material is in a path of a beam of neutron radiation or a suspected path of a beam of neutron radiation; and detecting light emitted by the scintillation material with the photon detector.