Probing ultra-low energetic neutrinos with metamaterials detectors

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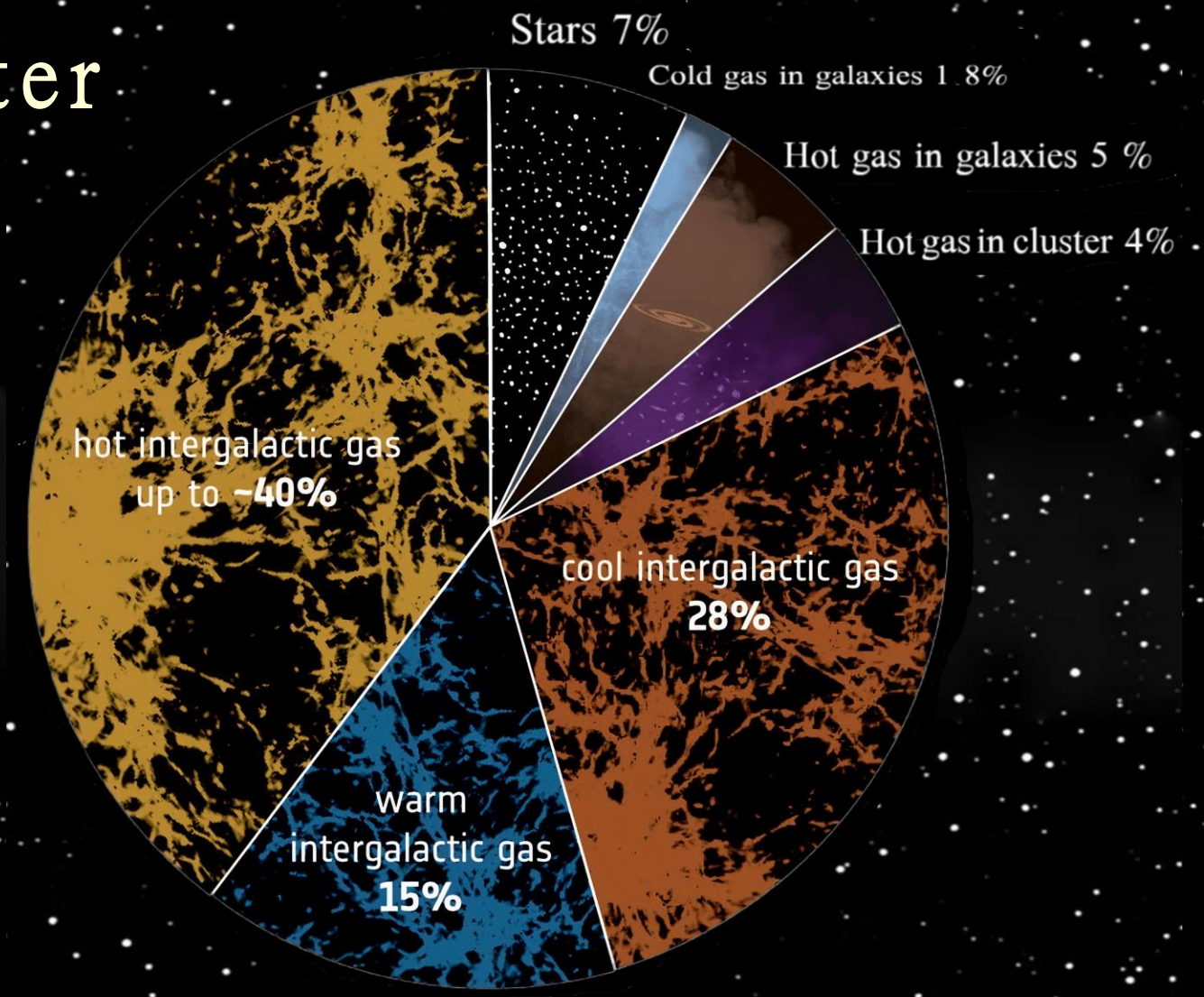
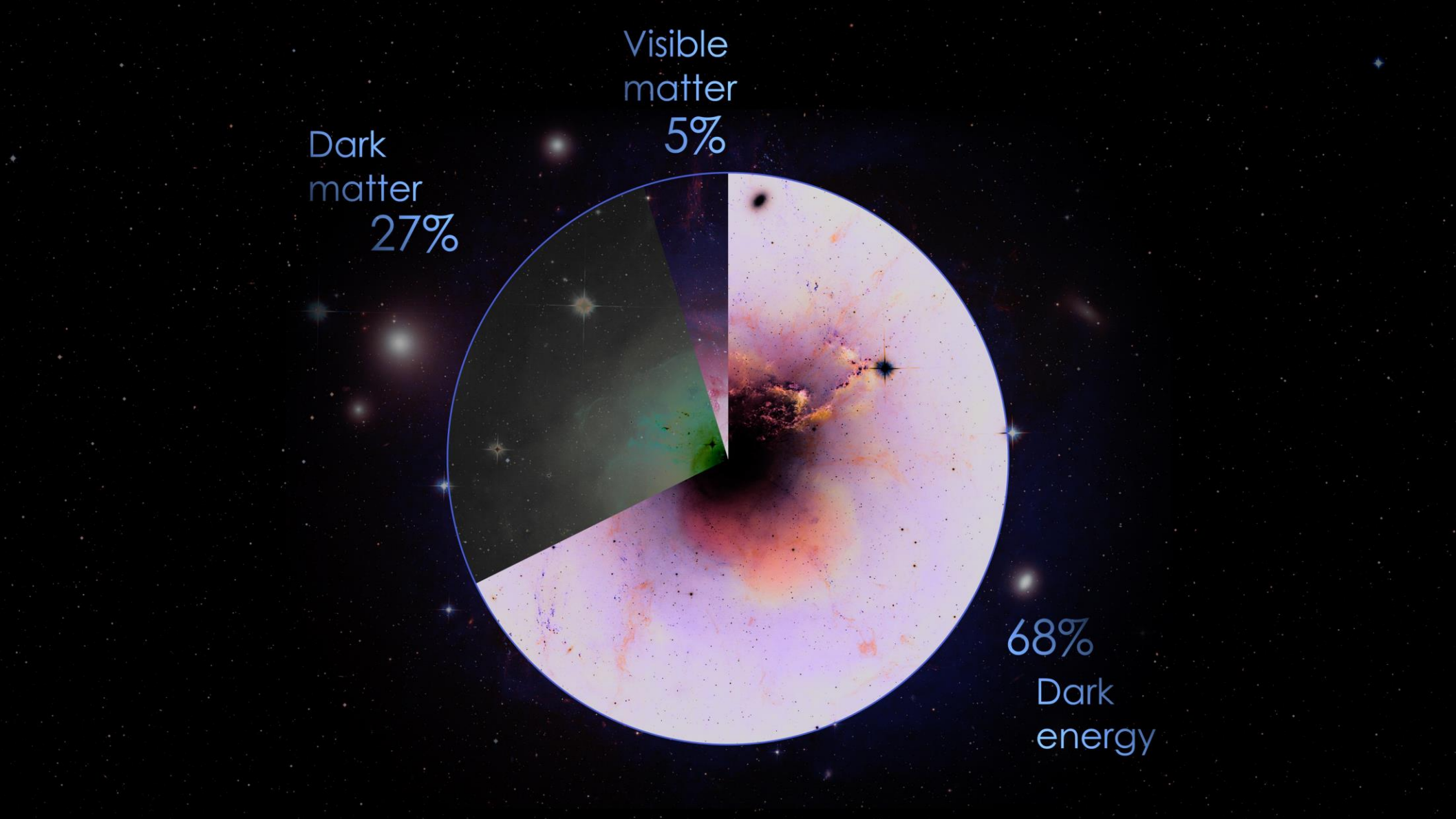
“It is Maya, the veil of deception, which blinds the eyes of mortals and makes them behold a world of which they cannot say that it is or that it is not”

— Arthur Schopenhauer, The World As Will And Idea

Visible Matter



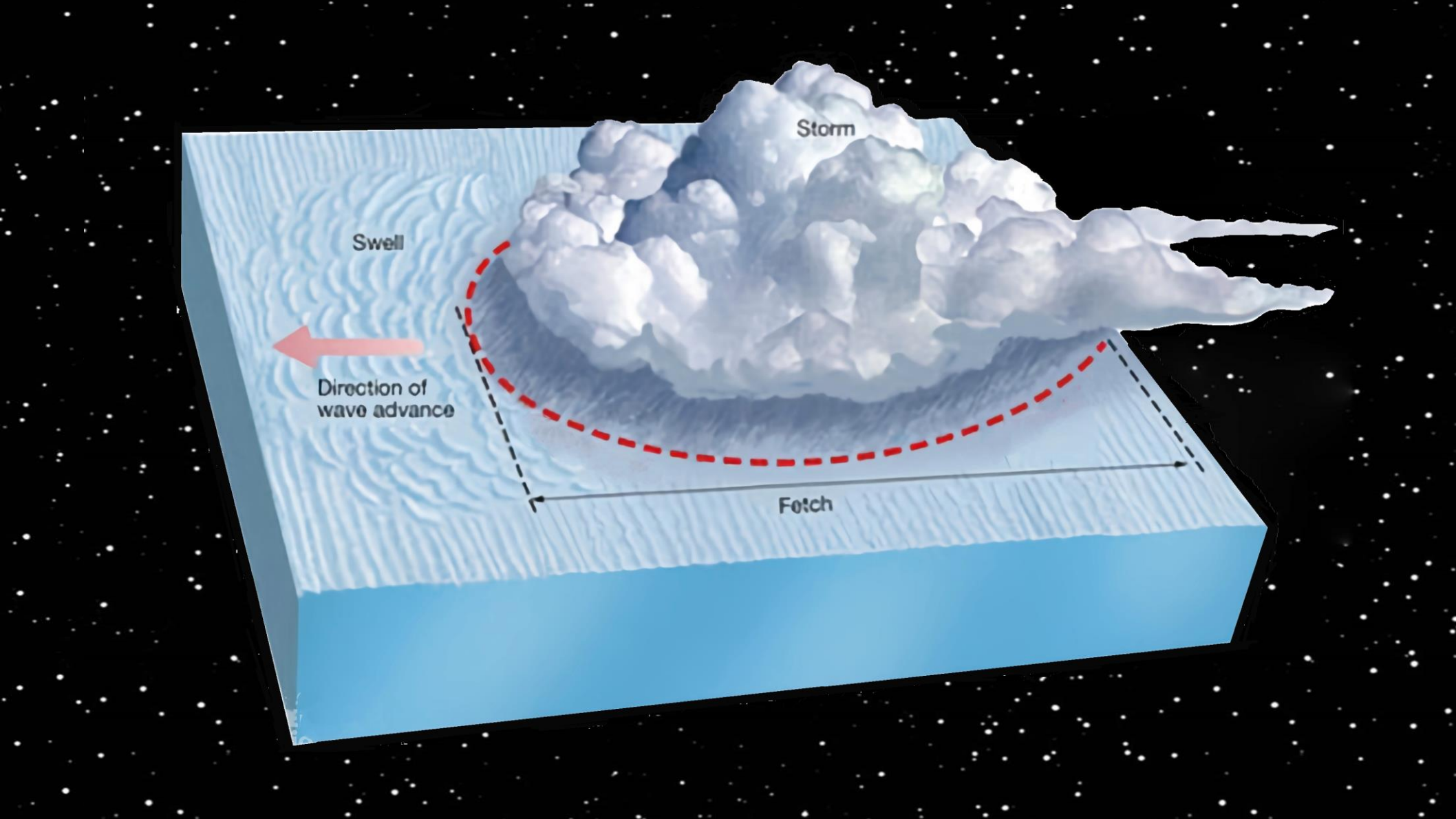

Visible
matter
5%
Dark
matter
27%
68%
Dark
energy

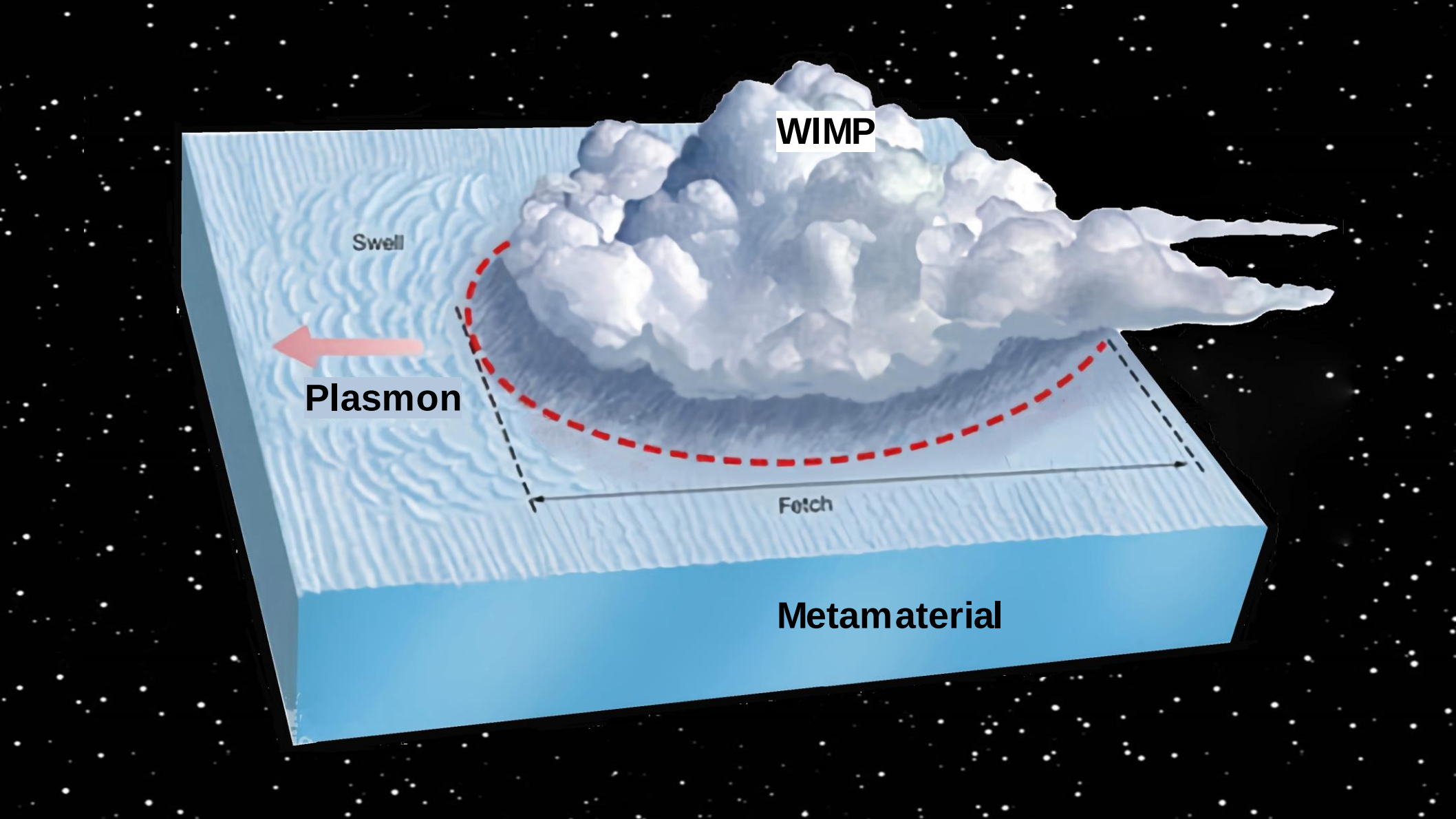
How can we understand

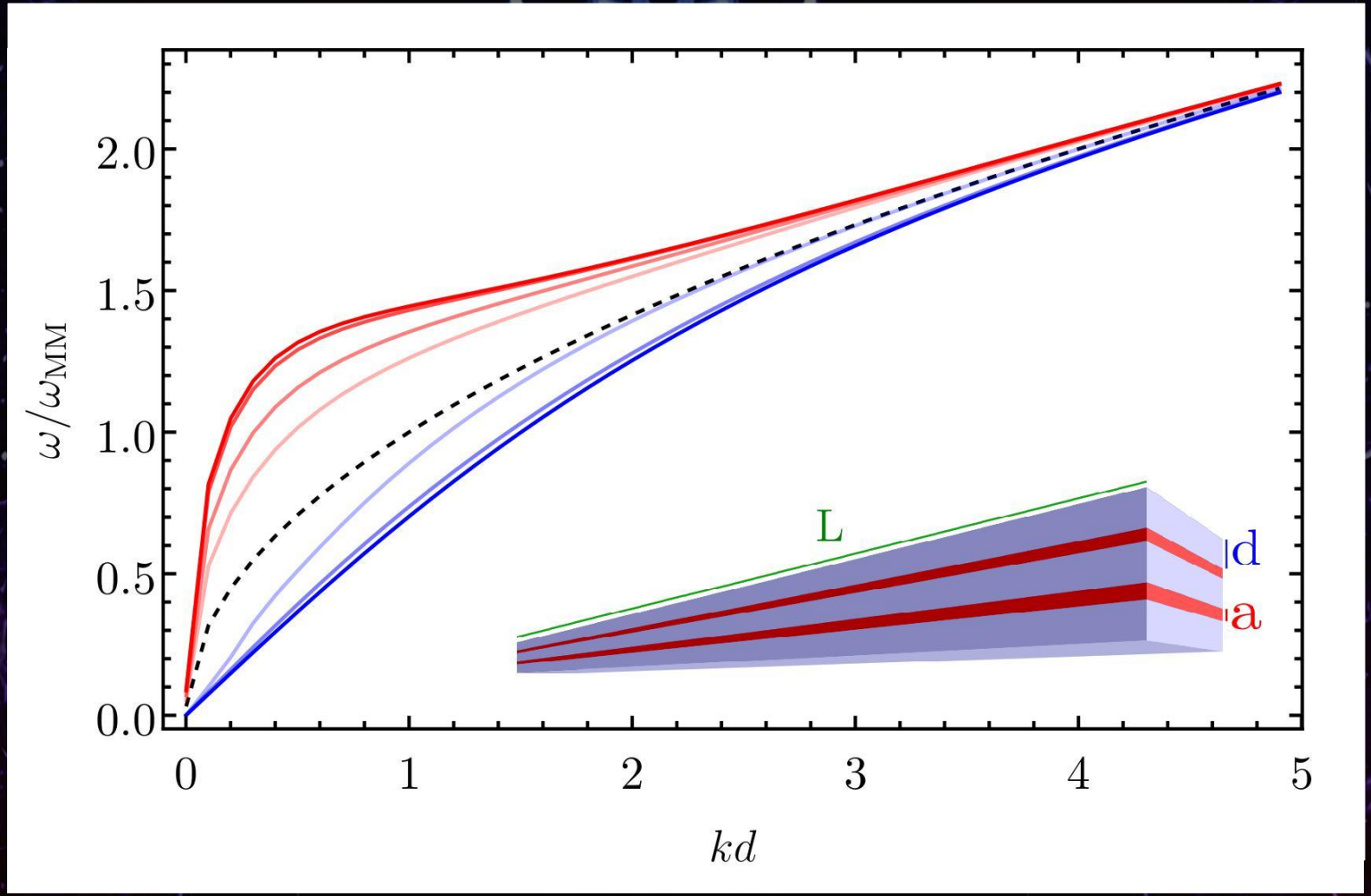
what we cannot sense?

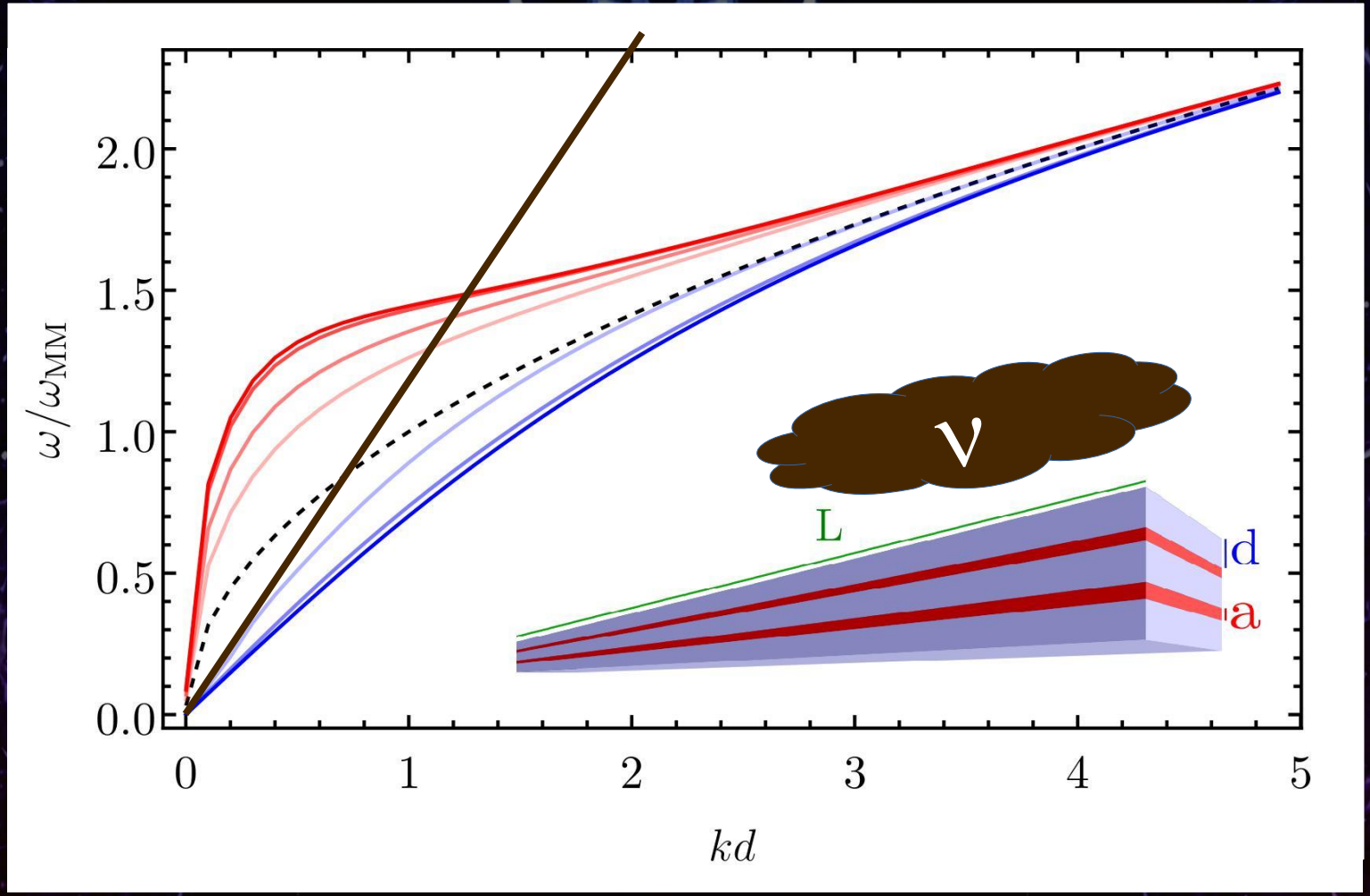
METAMATERIALS

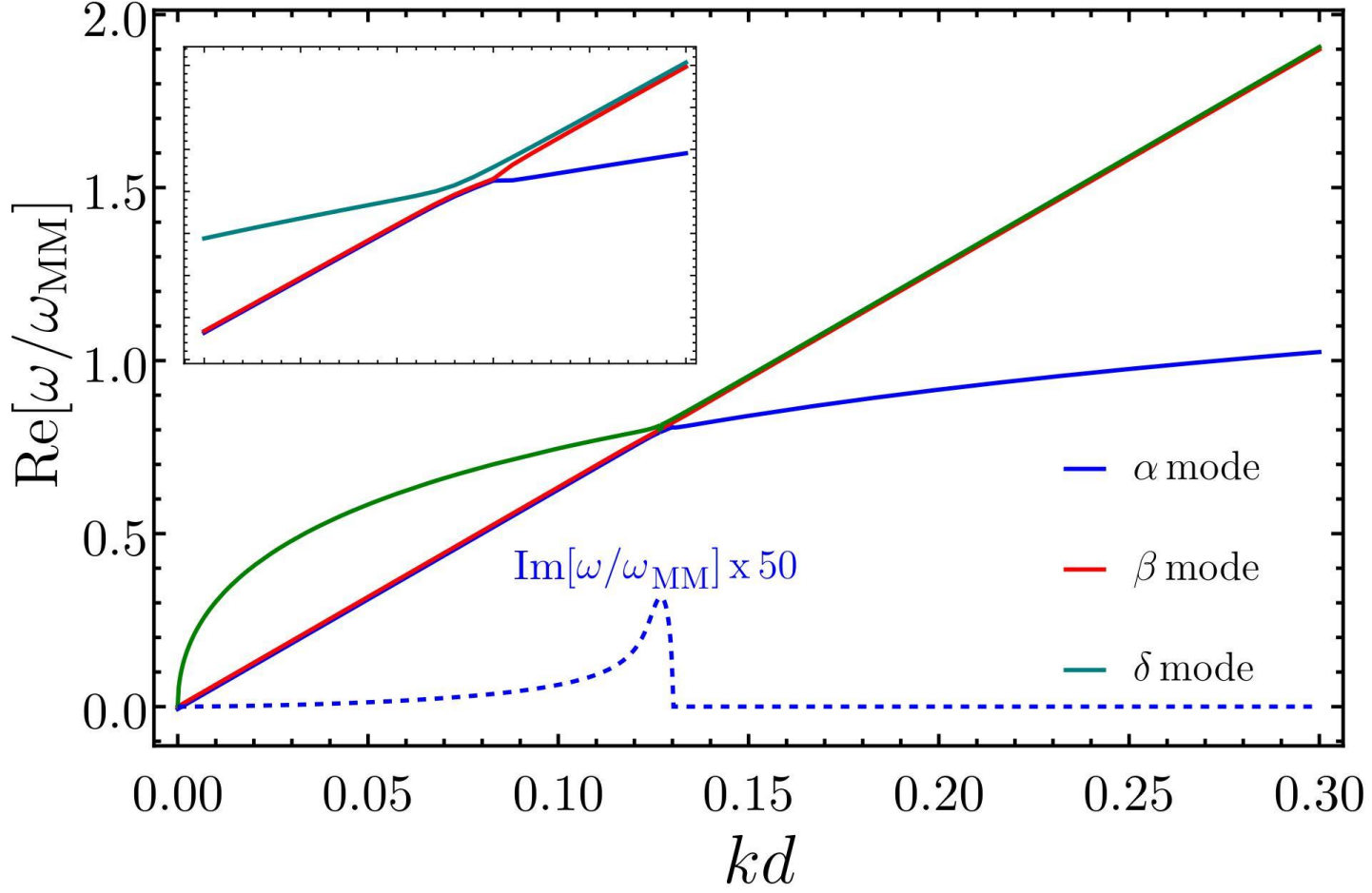
Metamaterials are artificial structures with unique properties, holding promise for sensing applications by leveraging nanoscale patterns to enhance detection precision and sensitivity.

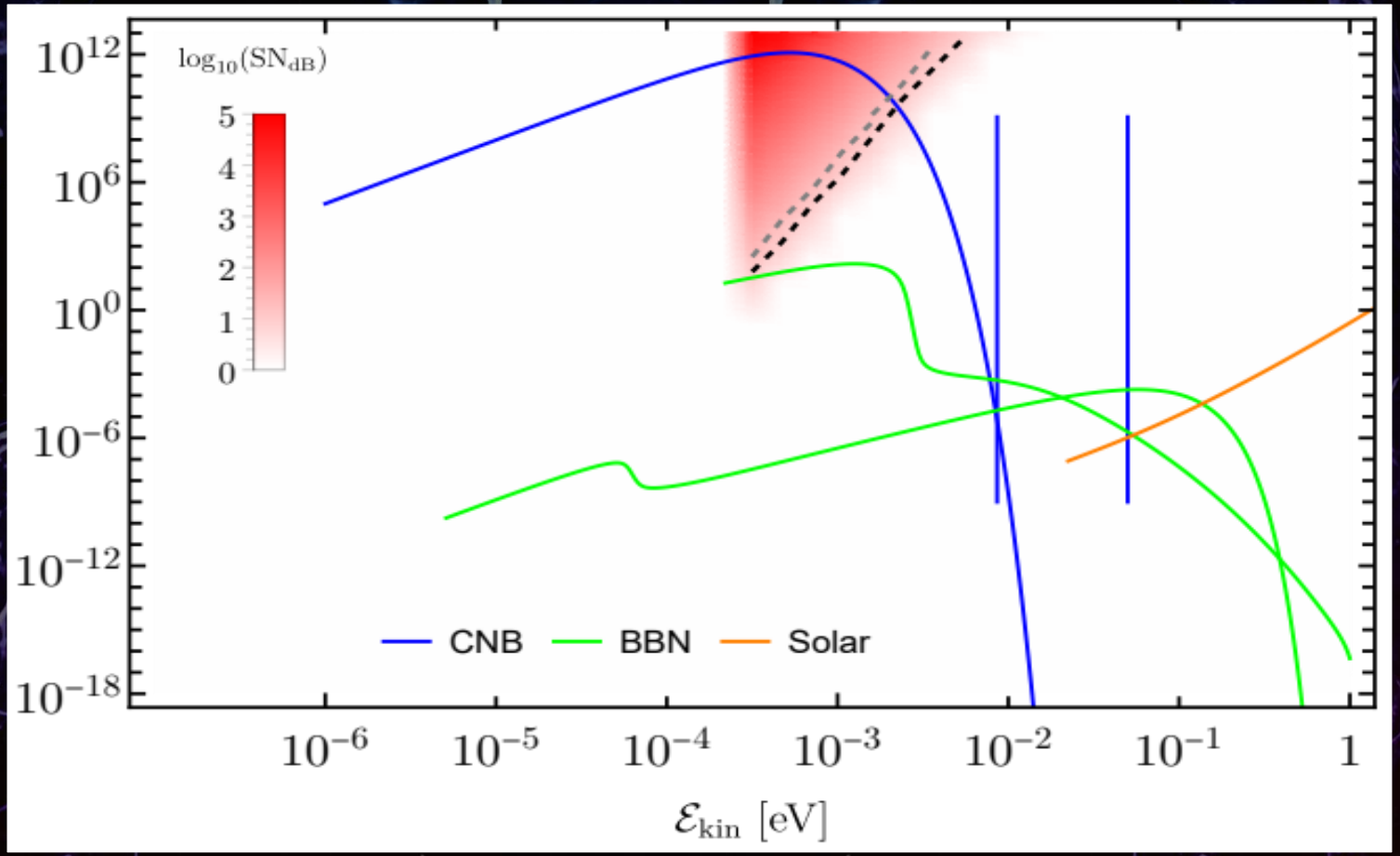

Storm
Swell
Direction of
wave advance
Fetch

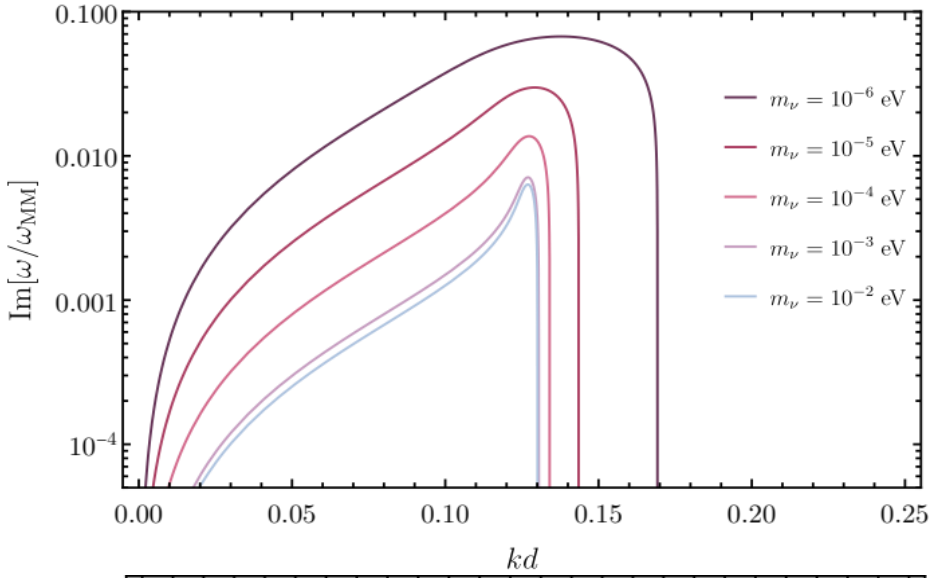

WIMP
Swell
Plasmon
Fetch
Metamaterial

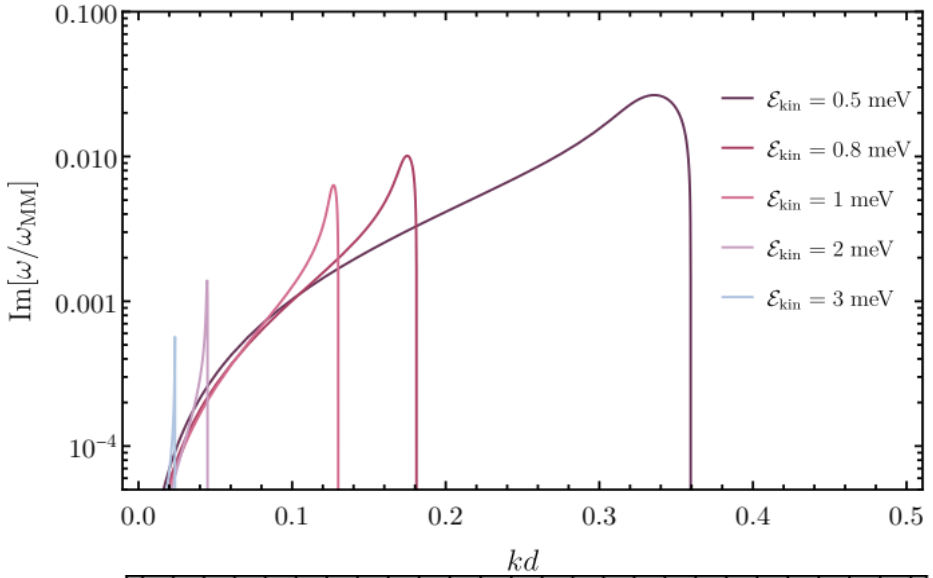

2.0
1.5
1.0
0.5
0.0
$\omega/\omega_{\mathrm{MM}}$
0
1
2
3
4
5
kd
L
d
a

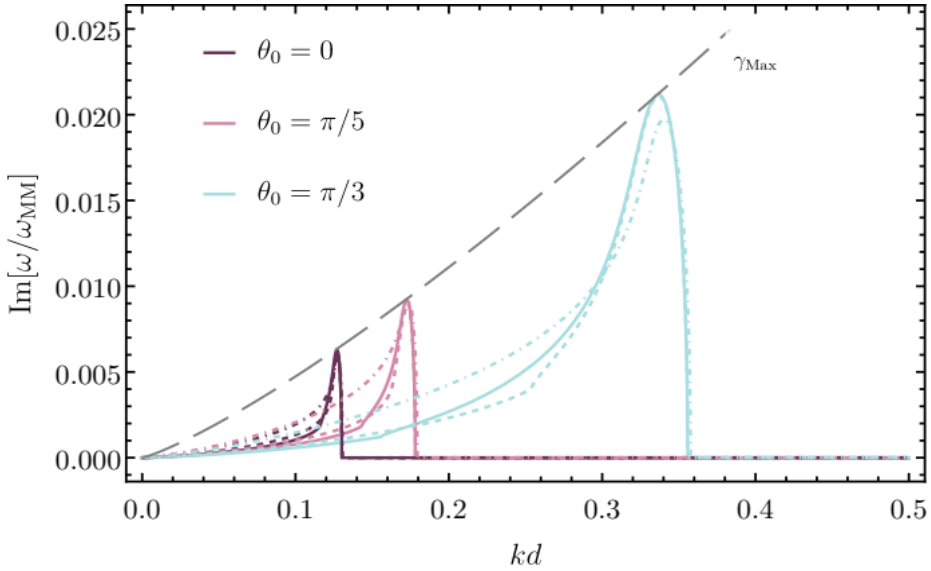

2.0
1.5
1.0
0.5
0.0
$\omega/\omega_{\mathrm{MM}}$
0
1
2
3
4
5
kd
ν
L
d
a

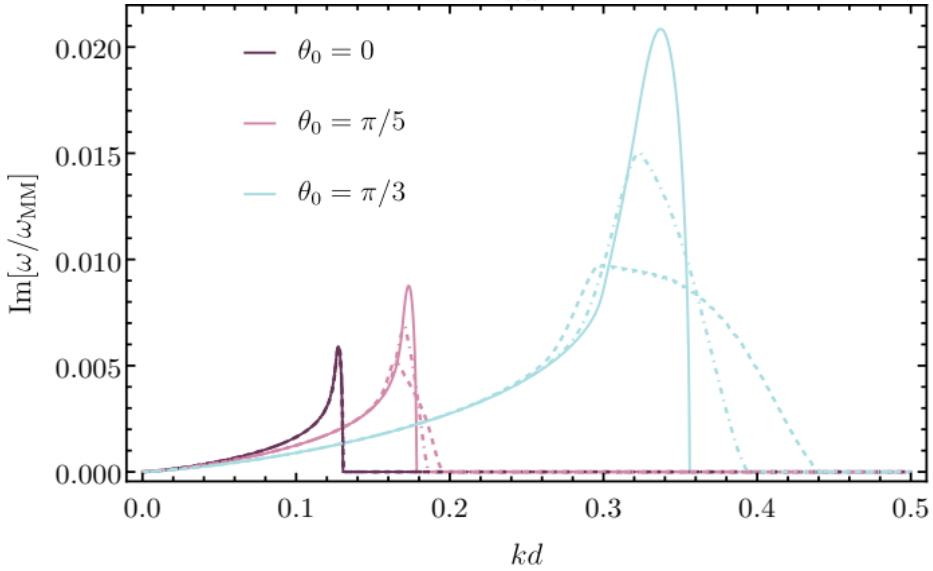

2.0
1.5
1.0
0.5
0.0
$\mathrm{Re}[\omega/\omega_{\mathrm{MM}}]$
0.00
0.05
0.10
0.15
0.20
0.25
0.30
kd
$\mathrm{Im}[\omega/\omega_{\mathrm{MM}}]\times 50$
α mode
β mode
δ mode


$\log_{10}(\mathrm{SN_{dB}})$
5
4
3
2
1
0
10^{12}
10^{6}
10^{0}
10^{-6}
10^{-12}
10^{-18}
CNB
BBN
Solar
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
$\mathcal{E}_{\mathrm{kin}}$ [eV]


0.100
0.010
0.001
10^{-4}
$\mathrm{Im}[\omega/\omega_{\mathrm{MM}}]$
0.00
0.05
0.10
0.15
0.20
0.25
kd
$m_\nu = 10^{-6}$ eV
$m_\nu = 10^{-5}$ eV
$m_\nu = 10^{-4}$ eV
$m_\nu = 10^{-3}$ eV
$m_\nu = 10^{-2}$ eV


0.100
0.010
0.001
10^{-4}
$\mathrm{Im}[\omega/\omega_{\mathrm{MM}}]$
0.0
0.1
0.2
0.3
0.4
0.5
kd
$\mathcal{E}_{\mathrm{kin}} = 0.5$ meV
$\mathcal{E}_{\mathrm{kin}} = 0.8$ meV
$\mathcal{E}_{\mathrm{kin}} = 1$ meV
$\mathcal{E}_{\mathrm{kin}} = 2$ meV
$\mathcal{E}_{\mathrm{kin}} = 3$ meV


0.025
0.020
0.015
0.010
0.005
0.000
$\mathrm{Im}[\omega/\omega_{\mathrm{MM}}]$
0.0
0.1
0.2
0.3
0.4
0.5
kd
$\theta_0 = 0$
$\theta_0 = \pi/5$
$\theta_0 = \pi/3$
γ_{Max}


0.020
0.015
0.010
0.005
0.000
$\mathrm{Im}[\omega/\omega_{\mathrm{MM}}]$
0.0
0.1
0.2
0.3
0.4
0.5
kd
$\theta_0 = 0$
$\theta_0 = \pi/5$
$\theta_0 = \pi/3$


Thanks for your attention

Bibliography

Fig1: Li, Qingsong et al. “Bio-inspired sensors based on photonic structures of Morpho butterfly wings: a review.” Journal of Materials Chemistry C 4 (2016): 1752-1763.

Fig2: Yaseen, A. A., Waqar, T., Khan, M. A. A., Asad, M., & Djavanroodi, F. (2021). Fish Scales and Their Biomimetic Applications. In Frontiers in Materials (Vol. 8). Frontiers Media SA.

Fig3: Lu, W., Si, M., Liu, H., Qiu, H., Wei, S., Wu, B., Wang, R., Yin, G., Zhang, J., Theato, P., Wei, Y., & Chen, T. (2021). A panther chameleon skin-inspired core@shell supramolecular hydrogel with spatially organized multi-luminogens enables programmable color change. In Cell Reports Physical Science (Vol. 2, Issue 5, p. 100417).

Fig4: Kuo, W.-K., Hsu, J.-J., Nien, C.-K., & Yu, H. H. (2016). Moth-Eye-Inspired Biophotonic Surfaces with Antireflective and Hydrophobic Characteristics. In ACS Applied Materials & Interfaces (Vol. 8, Issue 46, pp. 32021–32030). American Chemical Society (ACS).