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A Machine Learning-Enabled Study of Superconductivity

Application of the XGBoost Algorithm

Rajeev Atla

John P. Stevens High School

July 29, 2020

Outline

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   - XGBoost
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Ginzburg-Landau Theory

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Ginzburg-Landau Theory

- For a homogenous superconductor, the Ginzburg-Landau equation is

$$\alpha\phi + \beta|\phi|^2\phi = 0$$

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- The characteristic length scale ξ is called the Ginzburg-Landau coherence length

$$\xi = \sqrt{\frac{\hbar^2}{2m^*|\alpha|}}$$

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Types of Superconductors

- Two types - Type 1 and Type 2

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- Notation

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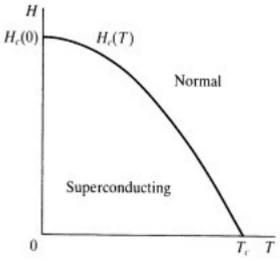

Figure: $H - T$ **phase diagram for a Type 1 superconductor [Tinkham]**

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Type 2 Superconductors

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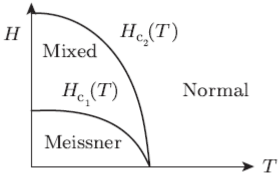

Figure: $H - T$ **phase diagram for a Type 2 superconductor [Girvin and Yang 2019]**

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Type 2 Superconductors: Abrikosov Lattice Vortices

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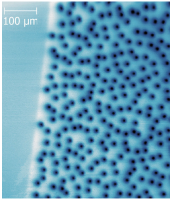

Figure: **Abrikosov vortices in YBCO - created by Wells et al. 2015 using scanning SQUID microscopy**

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$$\theta_f = \sum_j w_j \theta_j$$

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    - w_j are determined by backpropogation via gradient descent

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Figure: **UCI Machine Learning Repository**

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- XGBoost library
  - XGBClassifier class

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- Confusion matrix made using matplotlib library

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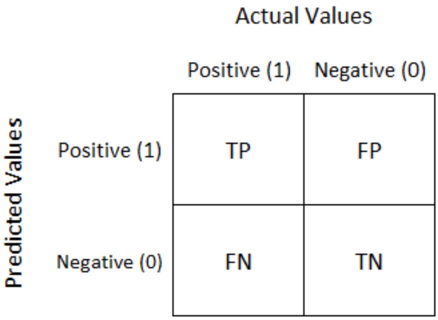

Figure: **Example Confusion Matrix**

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- Python training files, these slides, the dataset, etc. can be found at `https://github.com/RajeevAtla/Graphene-Research/`

Conclusion

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- Easiest way to access is using git

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