Inspiration from Physics

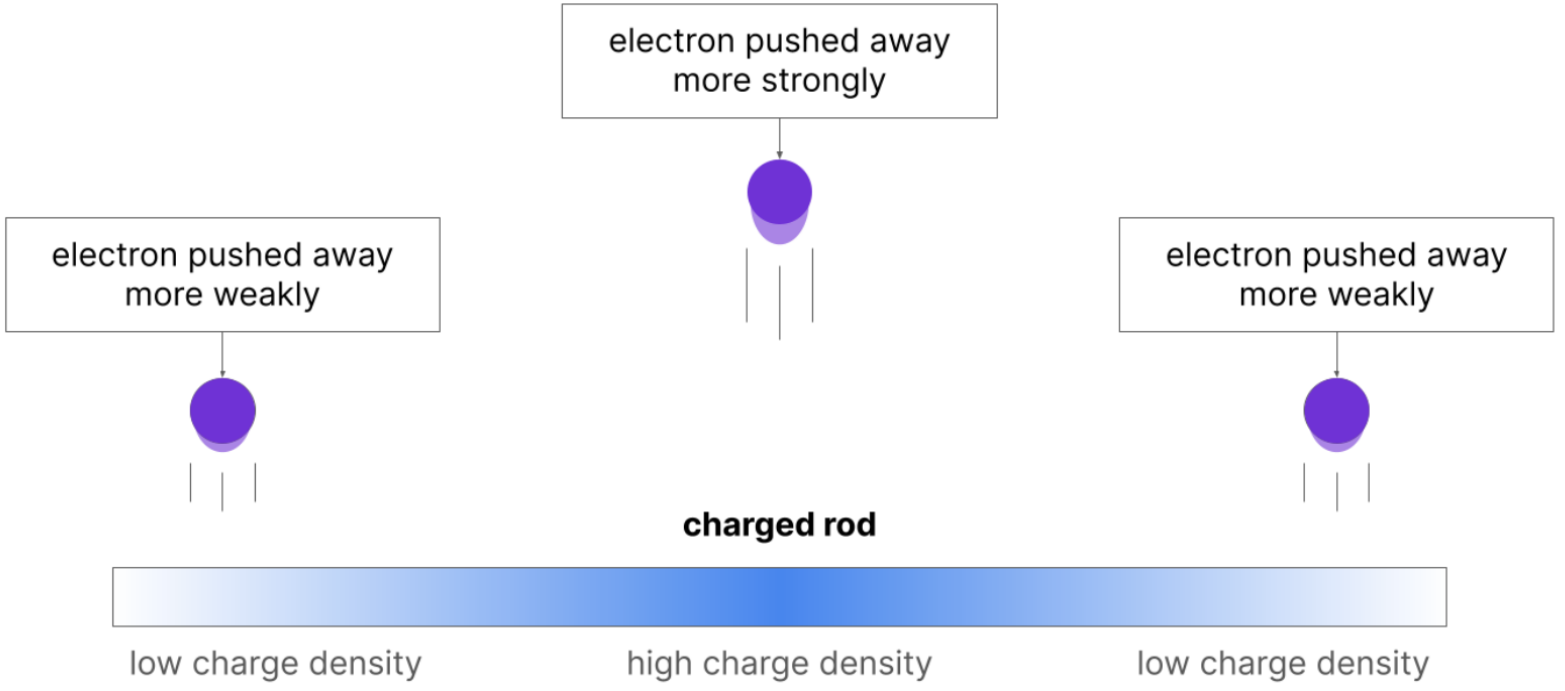
ACCELERATE PROGRAMME FOR SCIENTIFIC DISCOVERY

SCHMIDT FUTURES

Inspiration from Physics

Charge distributions

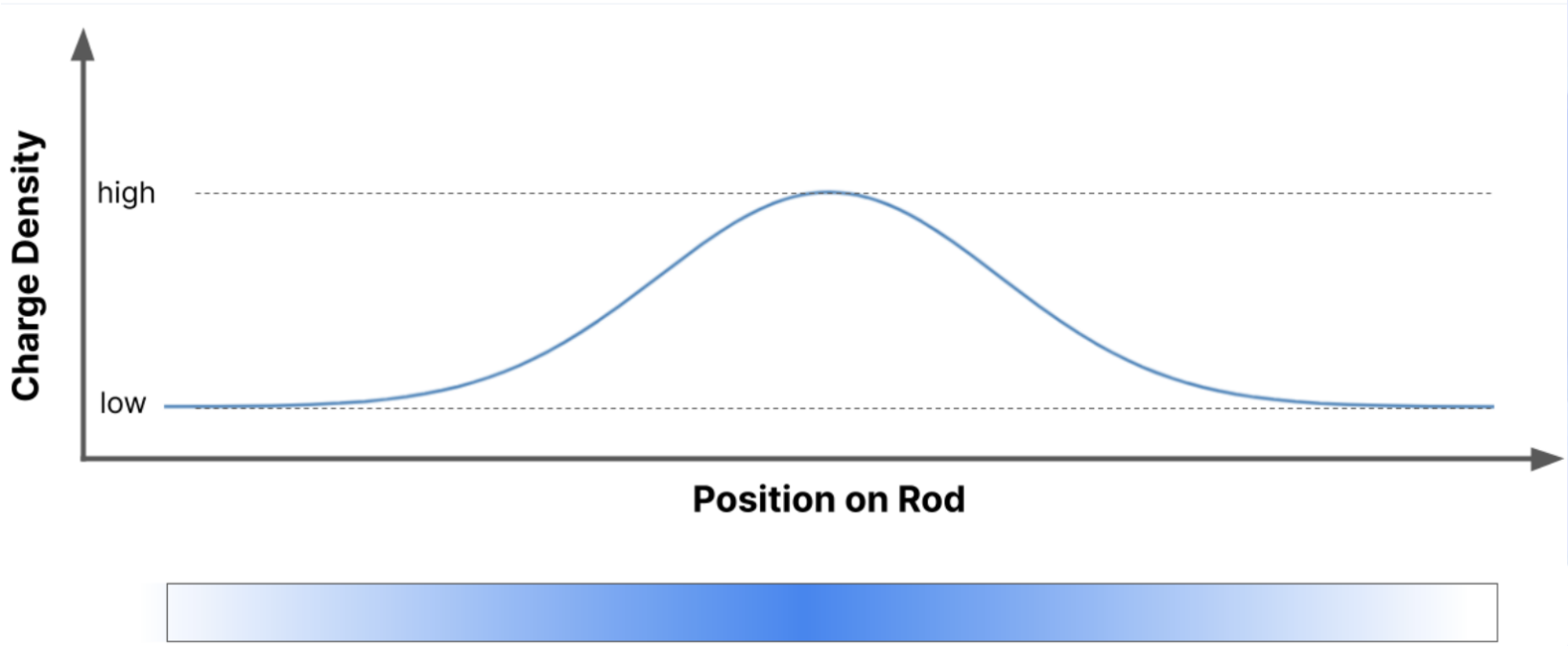
- Charge densities are objects that have different amounts of charge depending on where you are on the object.
- High charge repels electrons strongly, low charge repels electrons weakly:



Inspiration from Physics

Charge distributions

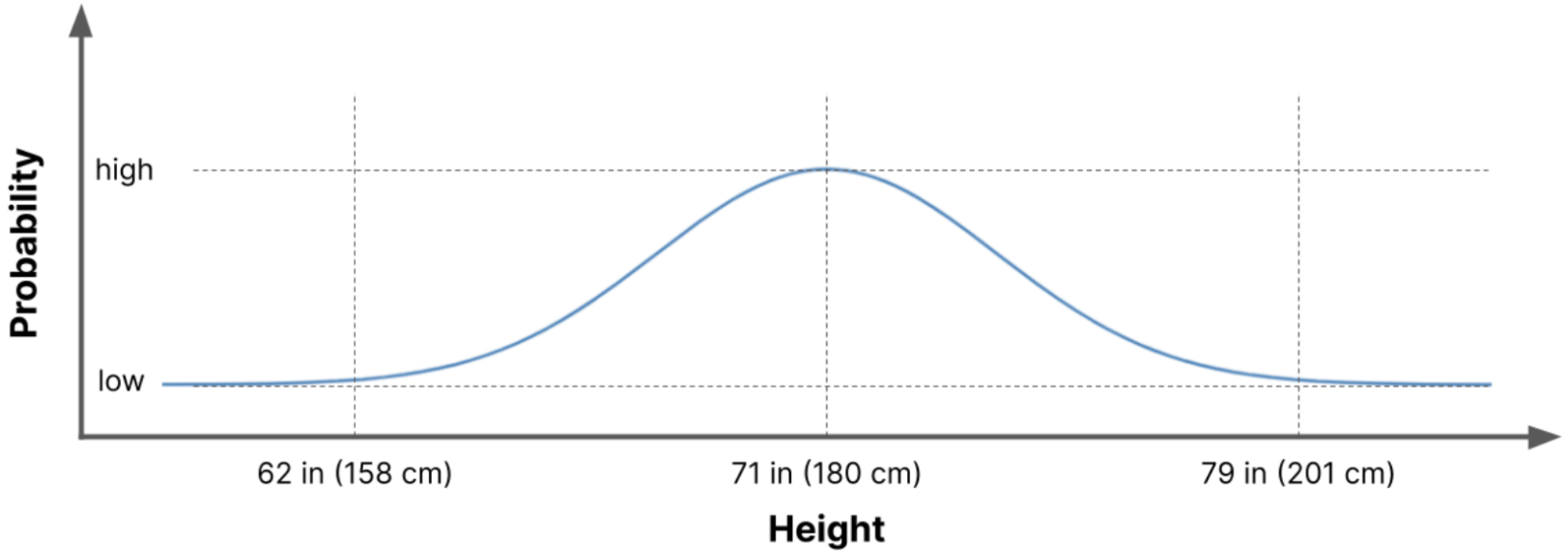
- If we plot the distribution in the previous slide, we get this distribution – a Gaussian (or Normal).



Inspiration from Physics

Probability distributions

- Instead of charge density, we can look at how likely the value of something is
- This probability density distribution shows the height of human males:



Inspiration from Physics

Generating new data

- Suppose now we want to generate new examples
- One idea might be to just draw randomly from this distribution.
- If the distribution is simple (such as a Gaussian), this is easy because we can write down the exact form of the distribution:

$$y = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2}$$

- So if we know the mean, μ, and the standard deviation, σ, then we can use some well-known (and very fast) algorithms for drawing from this distribution.

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The training data

- In our previous example, we gathered the heights of people and plotted the distribution.
- In doing so, we also calculated the mean and standard deviation.
- Our “model” can therefore be captured by only two pieces of information: μ and σ.
- This gathered data was the “training data”.
- We fit a model to this data.
- We can use this model to generate new examples of heights.

But what if the distributions are more complicated…

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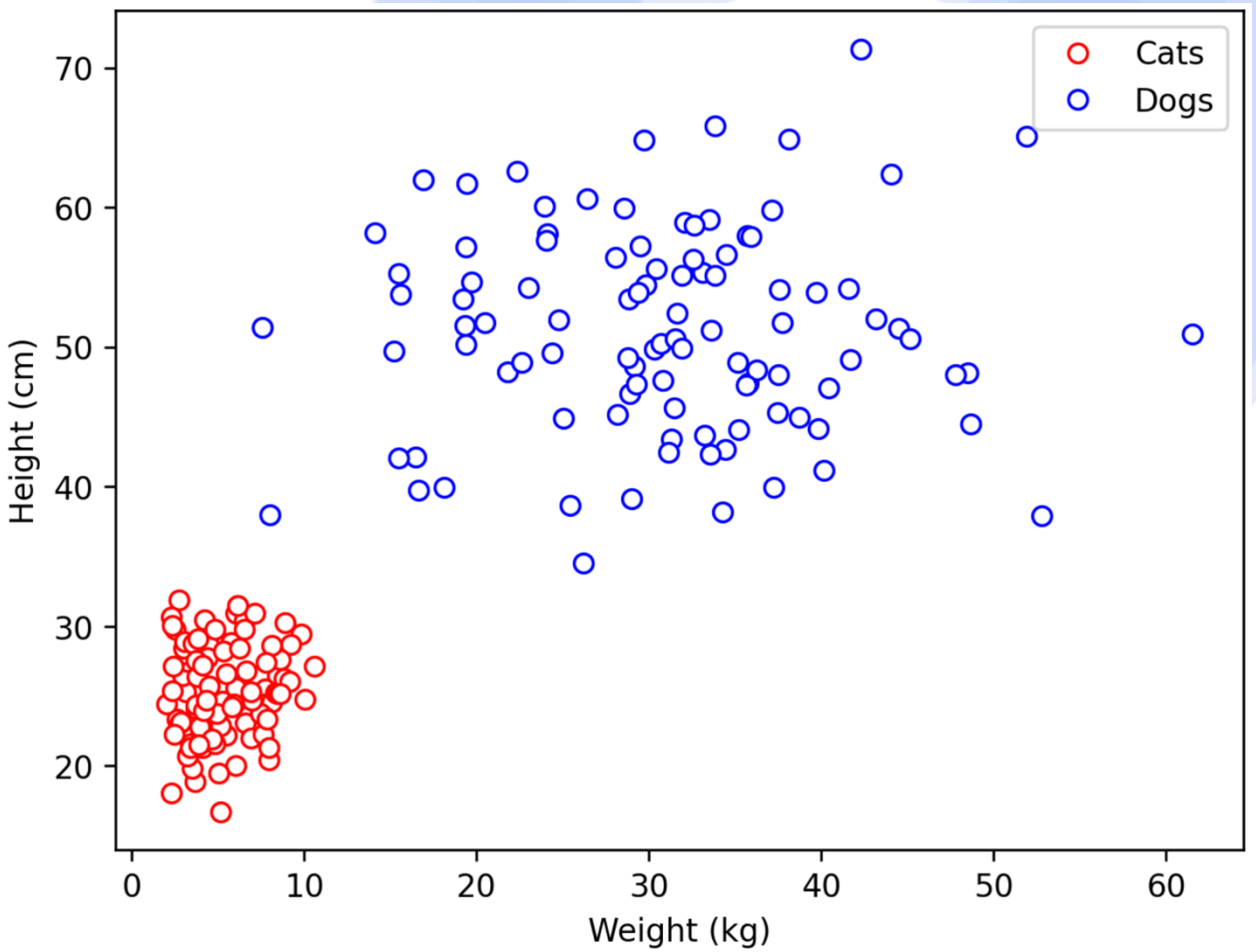
More complicated distributions

- Here is a plot of the height and weight distributions of cats and dogs
- Cats are typically smaller and lighter than dogs
- We don’t really see much variety in the size and shapes of cat, but dogs can vary quite a lot!



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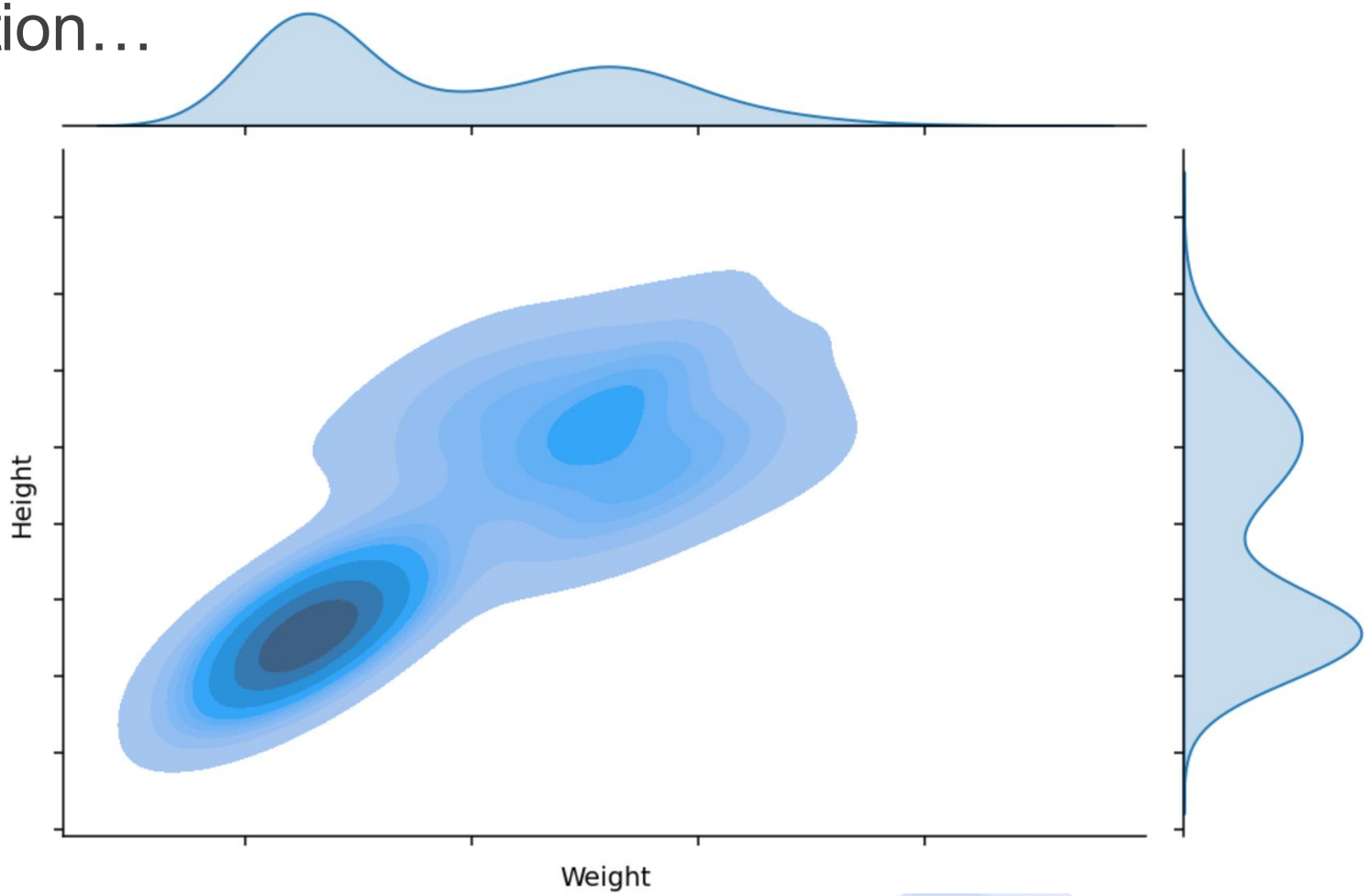
More complicated distribution…

- But how am I supposed to write down the equation to this distribution!
- I could guess, and say that it looks like a mixture of two Gaussians.
- But what about when we step into higher dimensions and I can’t physically look at the distribution of the data…?



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Let’s revisit the idea of data as a charge distribution…

- We have a complicated probability distribution
- Let’s now imagine that this is a charge distribution instead
- Areas of high charge are strongly repellent
- This will cause the distribution to “repel itself” and spread out
- As we let this happen for a very long time, it will be very difficult to make out any structure

- Here is an example:

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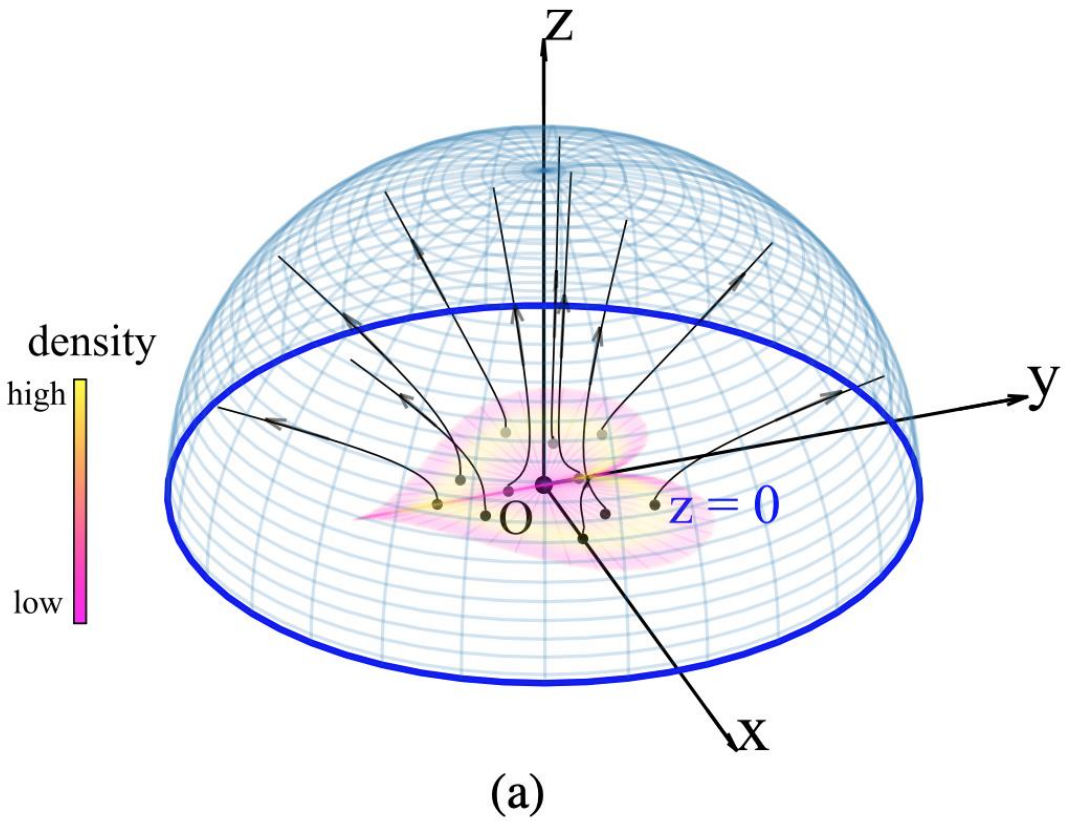
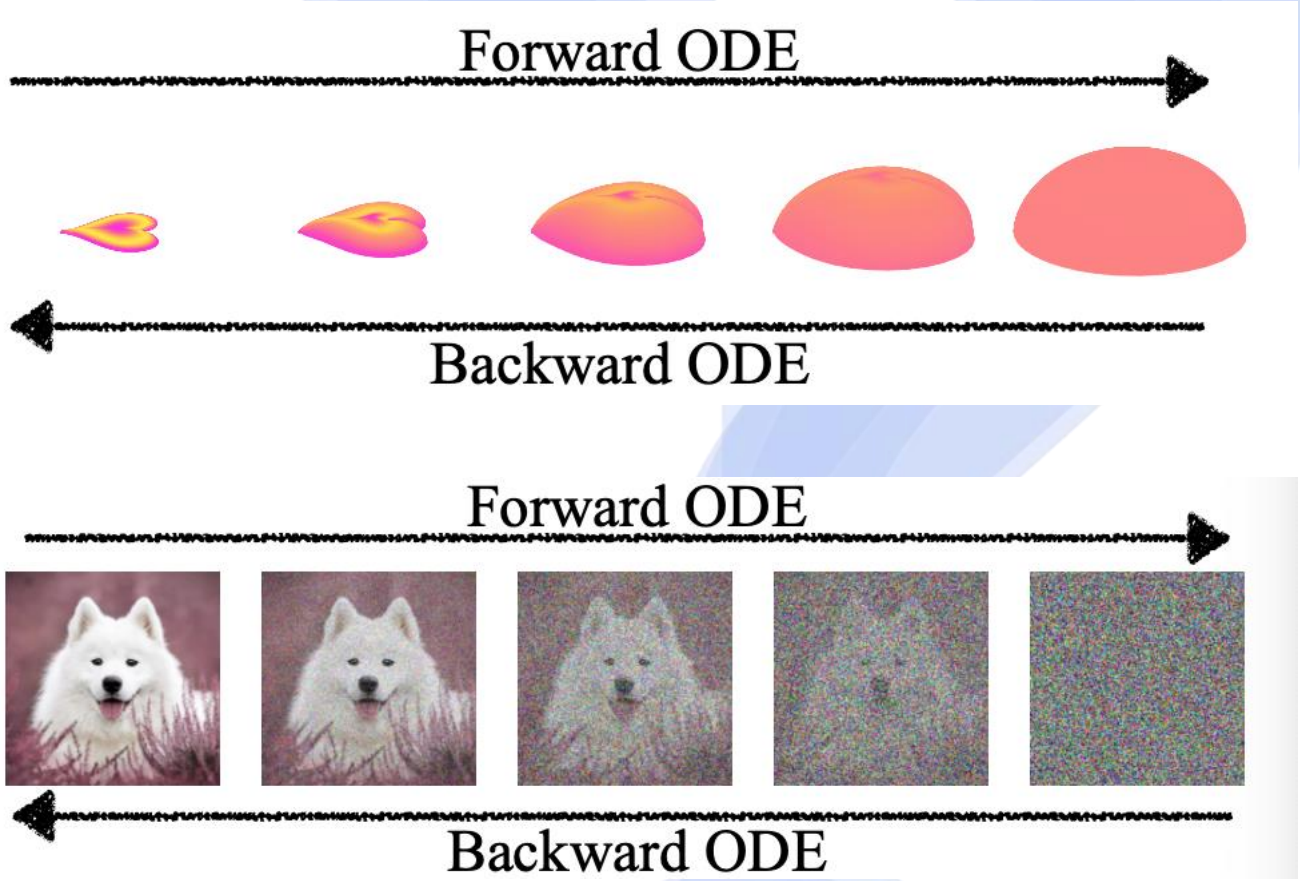
Start with a complicated distribution…



(a)



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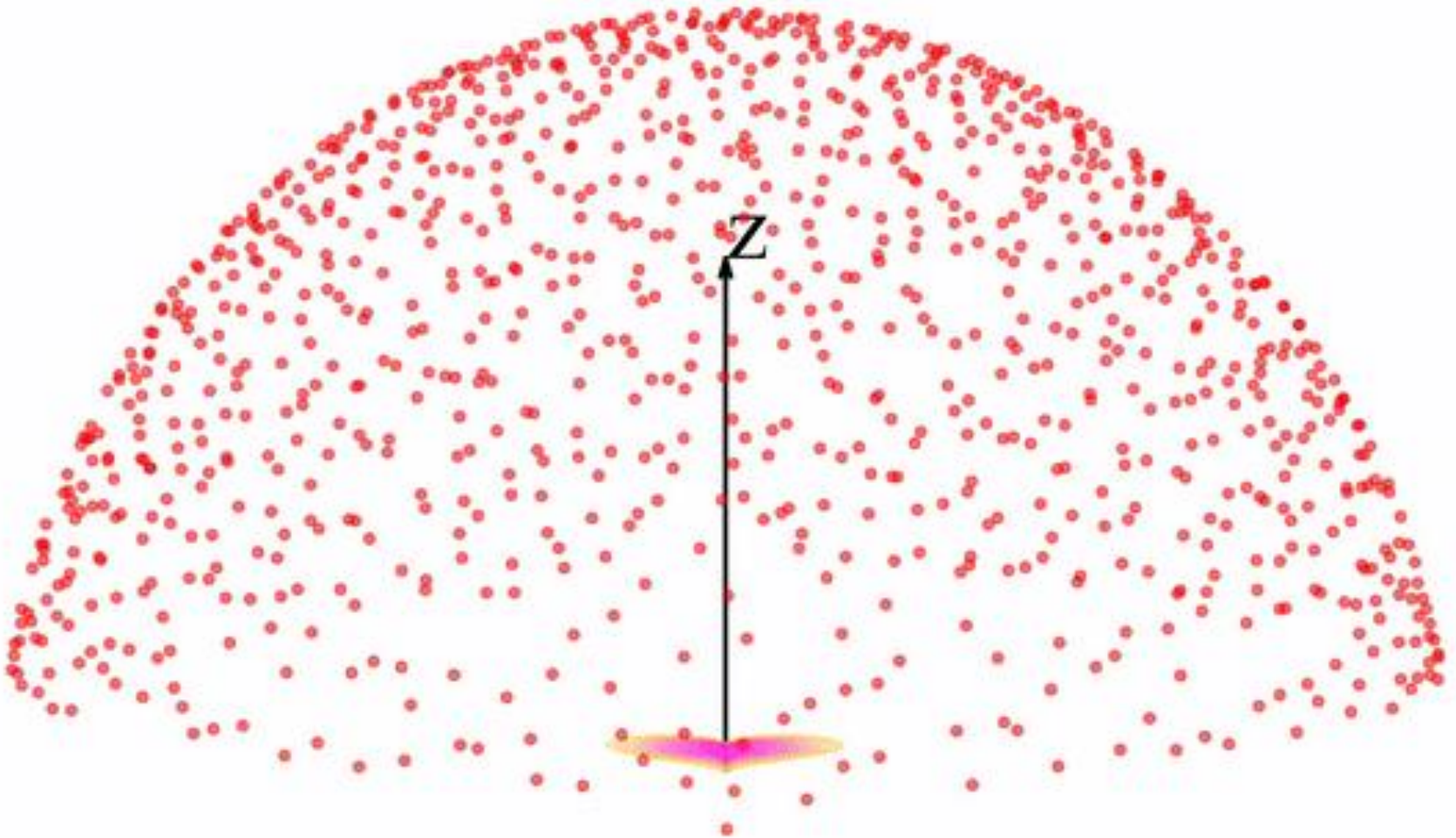

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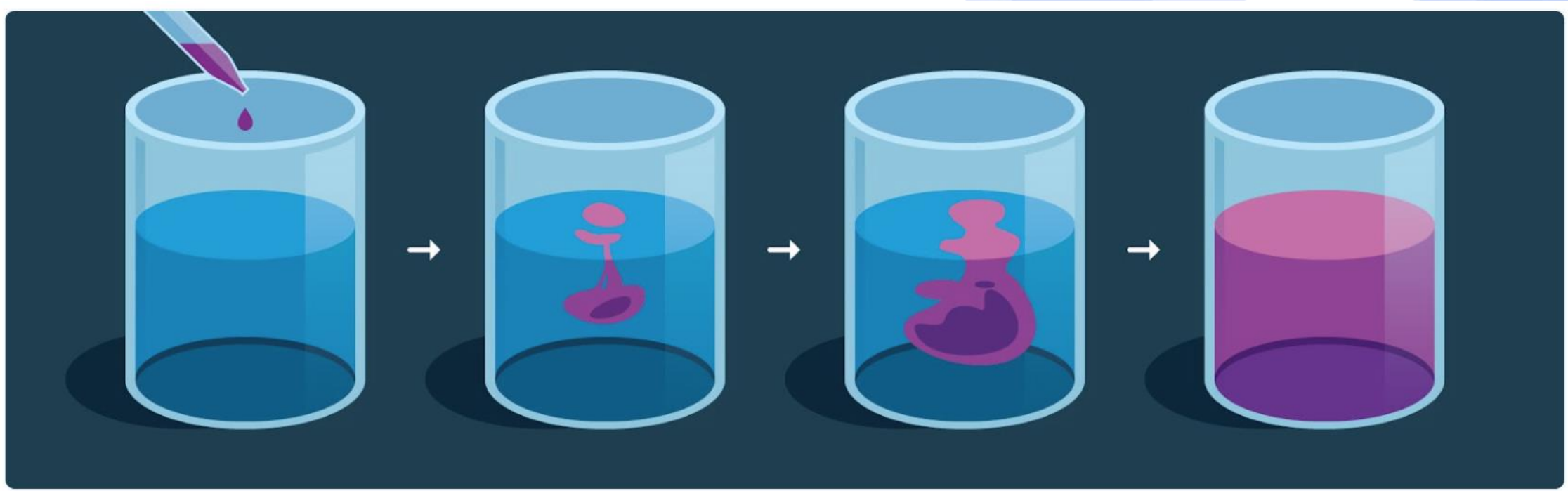
Another example, this time from statistical physics



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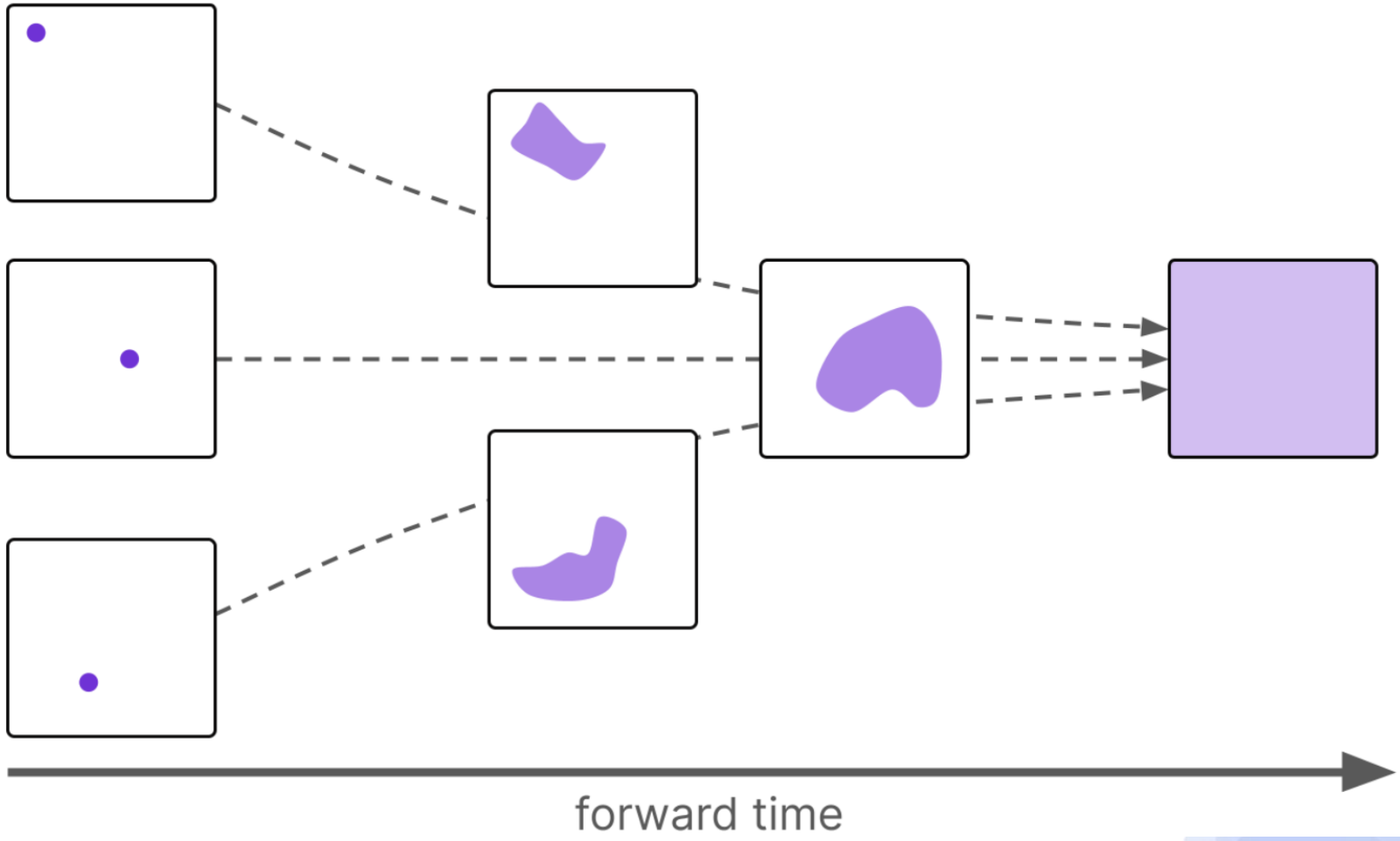
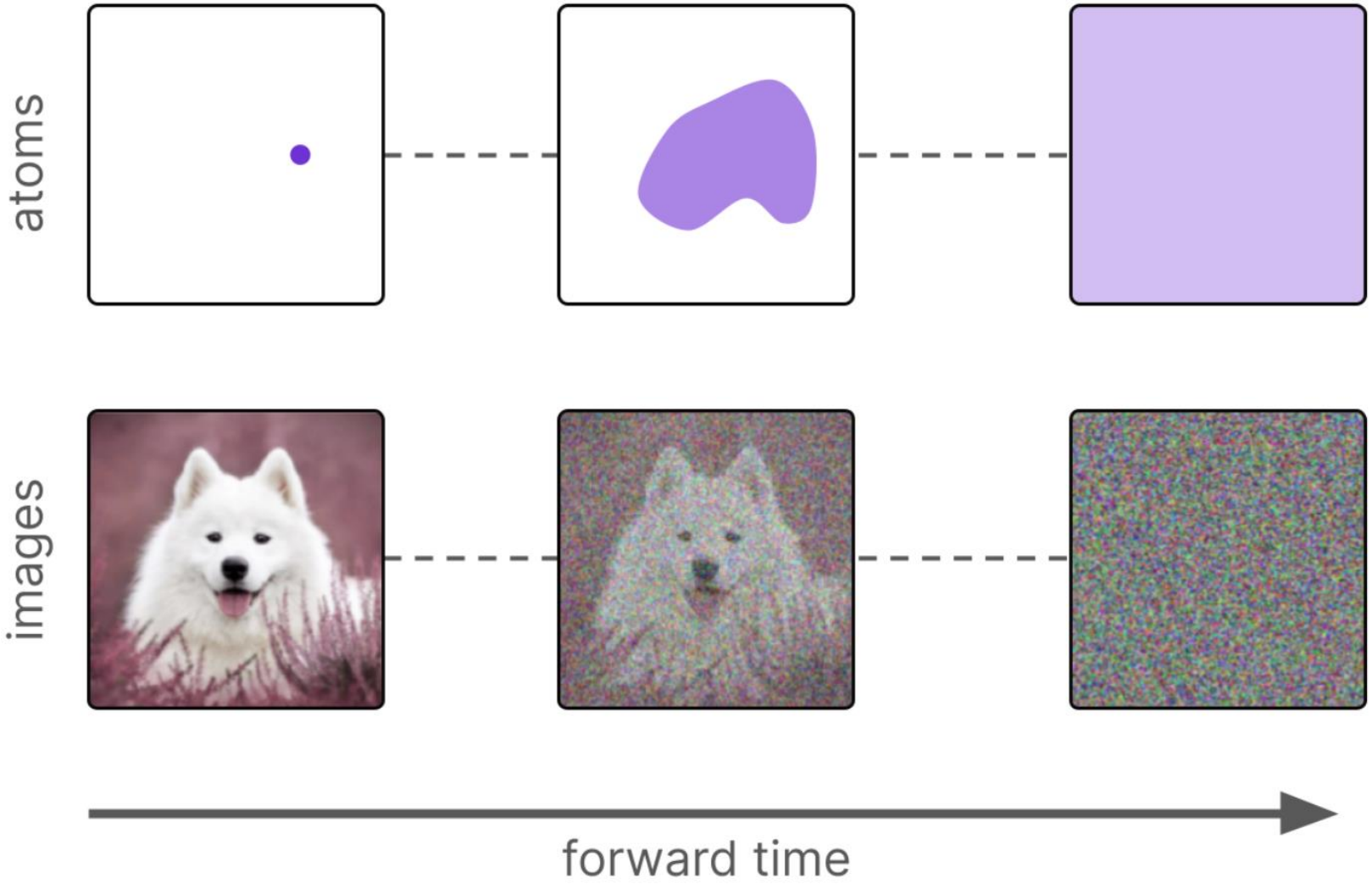
Regardless of where we place the initial milk drop, the end result is the same…



Inspiration from Physics

Coffee or pixels in an image…



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This is great, but why does it help us…?

- We saw with the cats and dogs, that it is difficult to sample from this distribution, because we cannot write down the equation of the distribution…

- But we ***can*** sample from a Normal distribution very easily…