

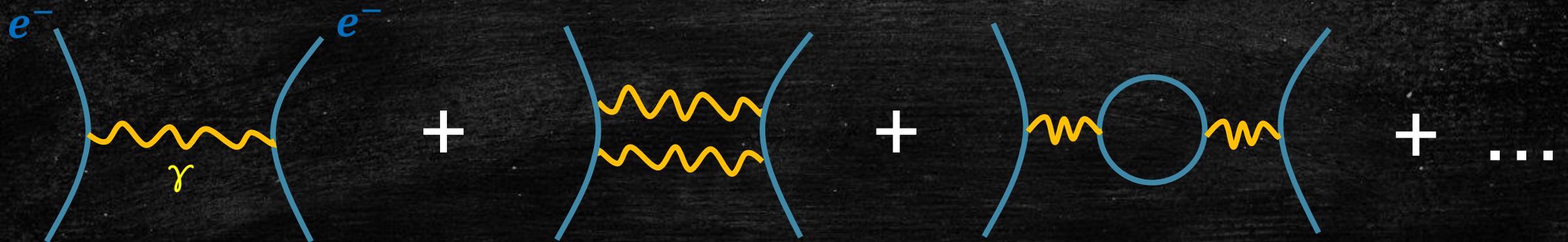
# Why do we need string theory?

(Linus Wulff)

A simple physical problem: *What is the force between two electrons?*

In the *standard model* the *electrons* are described as *point-like particles* and the *electromagnetic force* between them arises from *exchanging* another point-like particle – the *massless photon* ( $\gamma$ )

The *rules of quantum mechanics* tell us to *sum over all ways* this can happen. We represent this by *little pictures*:



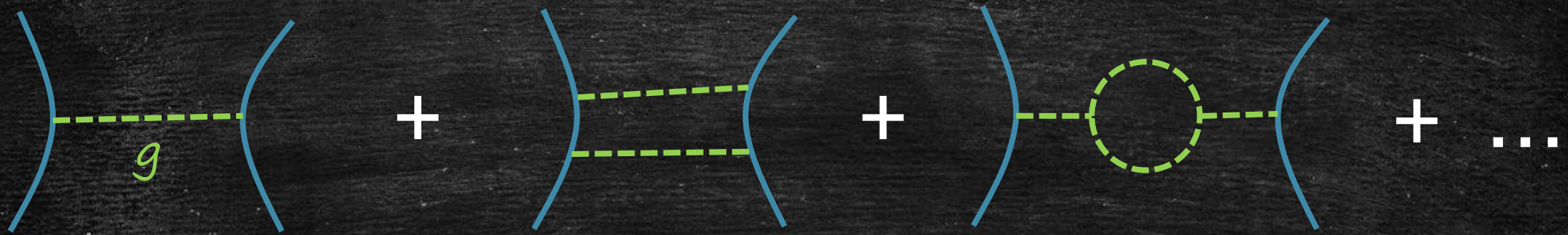
Each **picture** is associated to a **mathematical expression** and summing them up gives:

**Coulomb repulsion** + series of **quantum corrections**

The corrections can be computed to **great accuracy** and match with experiment to remarkable precision. This is a **great triumph** of 20<sup>th</sup> century physics.

However, electrons also have **mass** – there should be a **gravitational attraction** between them. Though it is too small to measure with current experiments we **should still be able to compute it**.

Following the **same rules** we introduce **another massless particle** – the **graviton** ( $g$ ) and draw similar pictures:



 **Newtonian attraction** +  $\infty$ !

This is a **big** problem! Our usual rules **cannot be applied to gravity**

There is only **one known solution**, and it is rather **drastic**:

**Replace**



Replacing *point-particles* by *little loops*, or *strings* (which are so *small* they look point-like to us) we should *calculate instead*:



Remarkably all the *infinities disappear* – the answer *now makes sense*



*String theory* is a consistent *quantum theory of gravity!*

But string theory has many more *surprises...*

- Space must have **six more dimensions**, i.e.  $3+6=9$
- There must exist a symmetry between **matter and forces** known as **supersymmetry**
- Our universe **breaks this symmetry** which means it must be quantum mechanically **unstable**

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If you are interested in learning more, or would like to do a thesis on something related, don't hesitate to contact me