Quirky long range communications

Can VERY exotic BSM “Quarks” have possible applications?

- Q: can a new BSM particle be TECHNOLOGICALLY useful? (like electrons or neutrons?) For this to be the case it has to be long lived and allow manipulation.
- Neutrinos ,muons magnetic monopoles come close but fail
- Still the answer is “may be yes”. An example is provided by “Quirks” for certain extreme range of parameters
- Review Quirk models and evolution of $Q'\bar{Q}'$ pairs produced at LHC
- Quirks connecting strings as Communication lines- possible obstacles.

- Quirks are “ WHY NOT” particles they do not resolve DM, Hierarchy S. CP or any other problem- but are not excluded theoretically nor by LHC searches, production by CR’s or Cosmology .
- who are the Q’s? Extend SM by adding another confining SU(N’) gauge group with a very low new scale Λ'=1-100 eV (Why later!) . Q’ are N’ of this gauge group and color triplets like quarks. N’ is 2 or 3. Higher values conflict with upper bound on # of light particles at nucleosynthesis. These charges make the Q’s are stable. .

- WE assume Λ' = 1-100 eV and M(Q') 1-3 TeV so that M(Q') ~ TeV > $10^{10}\,\Lambda'$!
- No real fine tuning issue . Mass of Q' like top mass is not QCD' generated. $\Lambda' \sim \exp(-b\_0/g'^2)$ So g' < g or N' =2 resolves it.
- The Pr C.S. in LHC is 2N' times that of a Squark of the same mass- 10^{-35}- 10^{-37} cm^2 so that
- 100 – 10^4 can be produced in the complete LHC running. (Far better than CR's!)
- The Q' and its anti-particle are connected by both QCD and QCD' strings. The first breaks after ~ 2 Fermi into $\bar{Q}'q$ and $Q'\bar{q}$ heavy M' and $\bar{M}'$ mesons.

The remaining QCD' strings are for ever!

The string break at a rate of

~ $\exp(-M(Q')^2/(\Lambda'^2)) = \exp(-10^{20})$

β' ps factor -→ Q' pair produced with cm kinetic Energy of T'= 0.1-0.3 M(Q')= 0.1- 1 TeV. Because of the linear attractive potential the M' M' separate to a distance $d(tp)=T'/(4\Lambda'^2)= 10^2- 10^7$ cm and keep yo-oing back and forth. In each traversal the light quarks interact and pion production leads to a loss of δ T'= 0.3 GeV and most Kin energy is lost in ~10^3 collisions after M'-M' system traverses 10^3 d(tp)=10^3 meter- 10^5 Km (in CR production time dilation- increases this by 10^3)

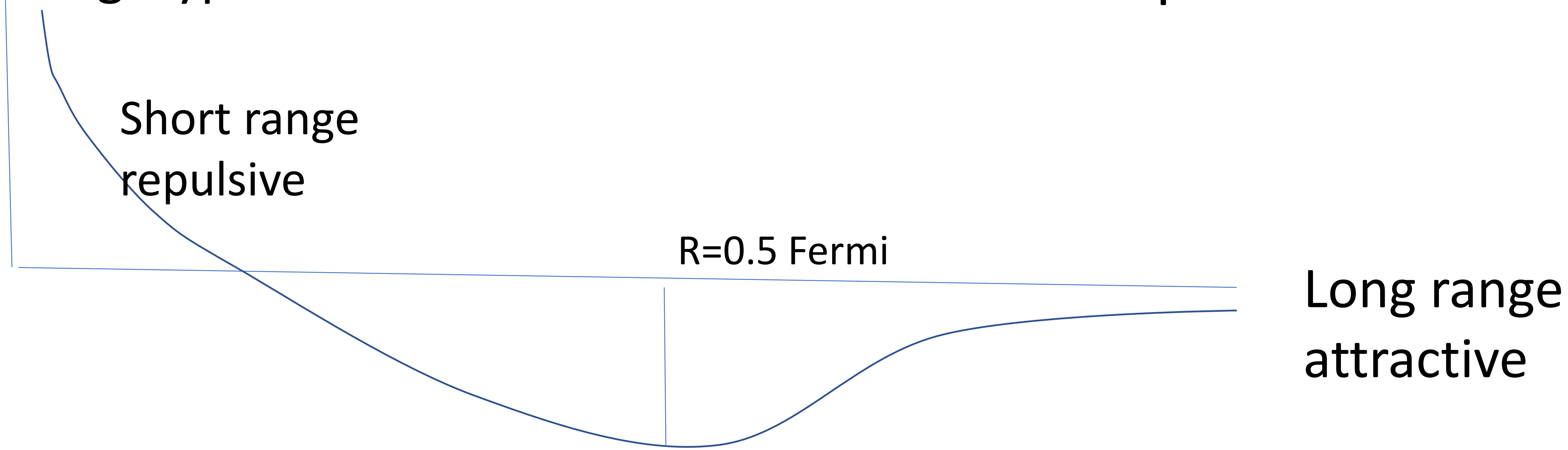
The slow $\bar{Q}'q - Q'\bar{q}$ collide and rearrange into $\bar{Q}'Q' + \bar{q}q$(=pion). The Quirkonium quickly cascades to its ground state and annihilates mainly to ordinary gg gluons

(Dramatic LHC signatures for higher Λ' and tighter Yo-Yos with annihilation inside the detector)

For our low Λ 's the $\bar{M}'M'$ escape into the rocks much before annihilation. Having a mfp for nuclear interactions of ~ 50 Cm with average energy loss of .5 Gev per collision they will stop after few hundred meters {at different locations due to the Yo-Yo phase also the $\bar{M}'$ interacts more strongly then M'.

End of story? No way!

$\bar{M}'=Q'\bar{q}$ bind to nuclei in the rocks, which, due to the reduced kinetic energy (by a factor 2A ~ 50!) much more strongly then for the case of K forming Hypernuclei. However here also $M'=\bar{Q}'q$ also binds!



R(M'-N) optimized to maximize binding potential with small KE penalty . The fuzzy nuclear surface reduces the effect. Still few tens of MeV binding is expected

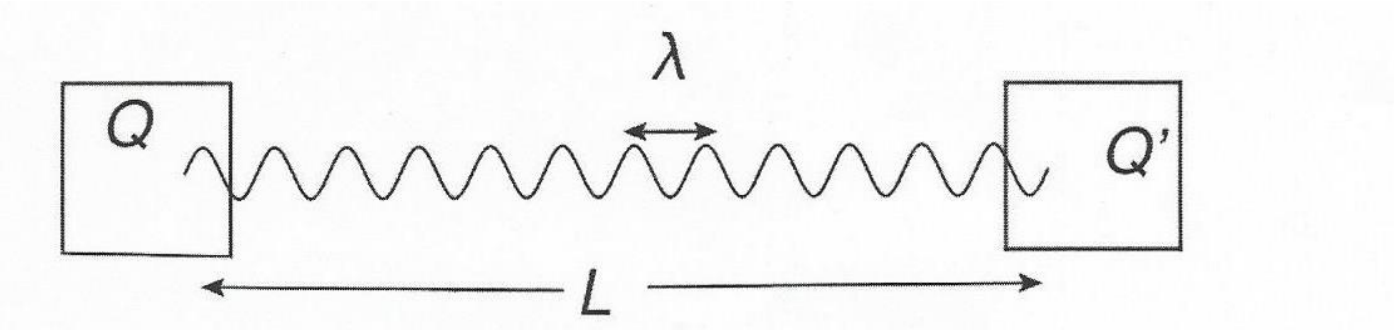
The (A,Z M’) systems are attached to Z electrons and these Heavy atoms will be lodged into crystal grains. For tensions lower than the force holding this atom in the grain :

Tension< 100 eV / (10^{-8} cm) ~ 10^5 eV^2

the atom stays in the grain (hence the low *Λ’* scale required).

With Q’ and Q’ embedded in different grains -Bob holding Q’ can send messages by say – up down oscillations of his grain. The resulting transverse waves move with velocity of light:

$$c(\text{string}) = (\text{Tension}/\text{density})^{1/2} = c$$



In principle for N'= 3 we can have much more complex multi participant net-works.

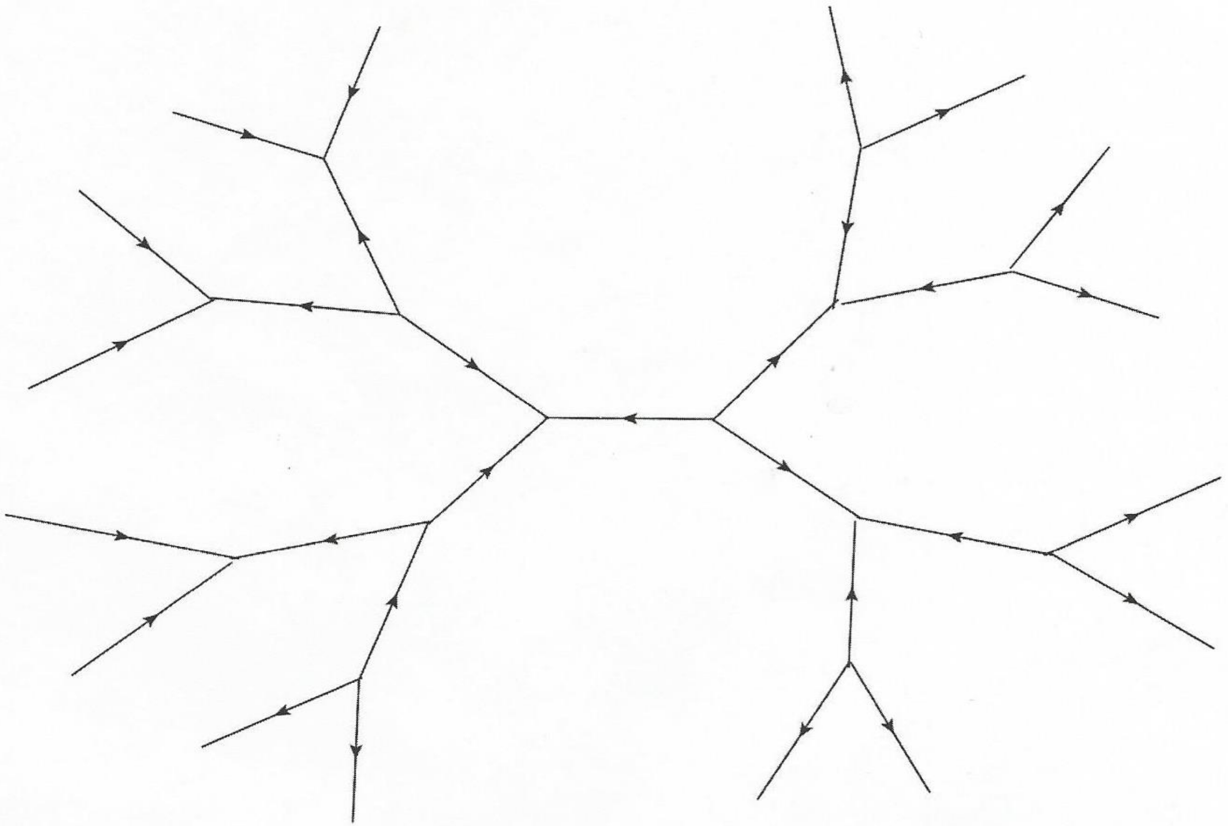


Figure 4: A string communication network for $N' = 3$.

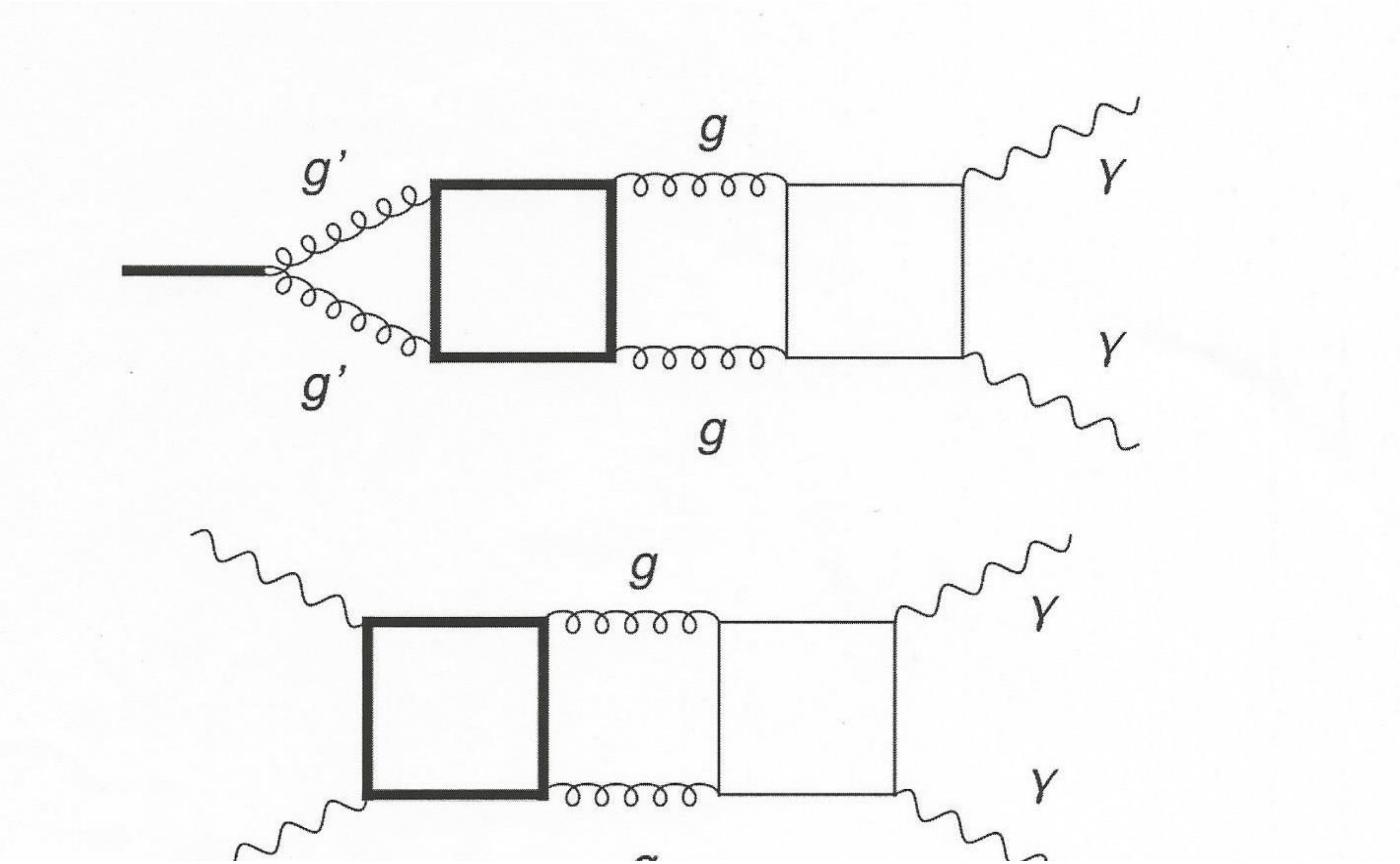
Amusing comment : The left half of the fig can be viewed as a nine quark exotic arrangement of 3 QCD baryons which after L/c delay is picked up in the second grain of Alice.

Unlike the case of e.m. radio waves or lasers there is NO geometric $1/L^2$ signal attenuation allowing safe Point to Point (even across the whole earth !) communications at arbitrary distances.

Possible obstacles: 1) Dispersion 2) collisions with C. background gb's 3) " Rogue strings" produced in the interstellar medium.

We do not have ideal, infinitely thin, string and different frequencies propagate with different velocities. With $e = \Delta c / c \sim (d/\lambda)^2$ distortion is avoided if $eL < \lambda$ so that for $f < 10^7$ distortion is negligible for up to L=Kparsec

At $T' = \Lambda'$ QCD' confines the g's into gb's. with decay time longer than $10^{-19} (M(Q')/\Lambda')^8 = 10^{50}$ Sec .



The strong gb’-gb’ interactions $\boldsymbol{\sigma} \sim \pi/(m(gb)^2) > 10^{-16}$ cm^2

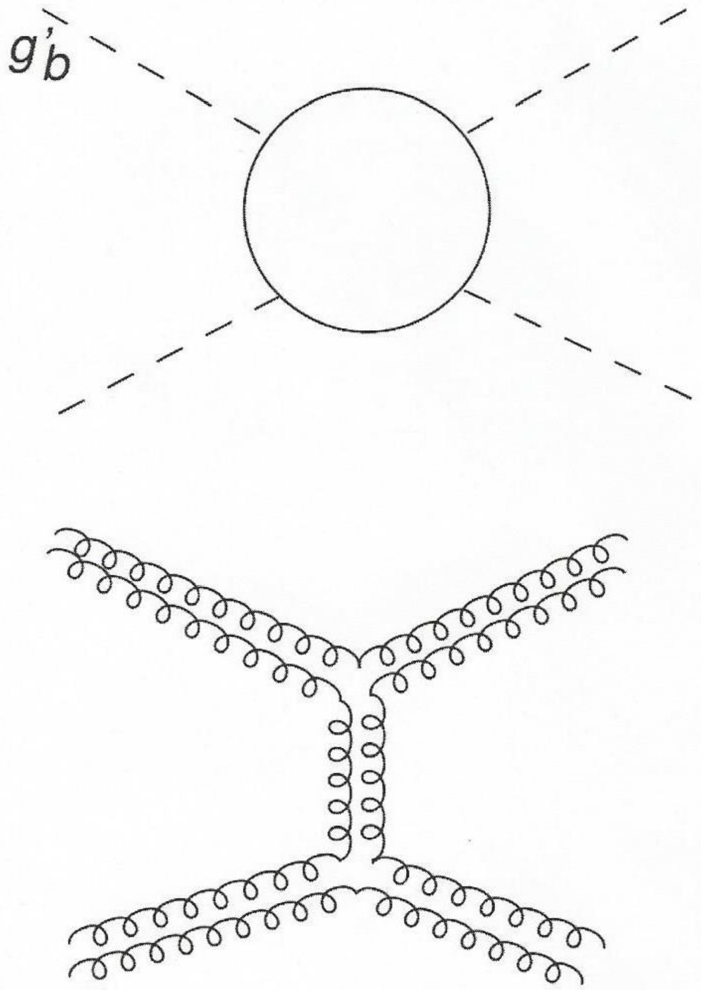
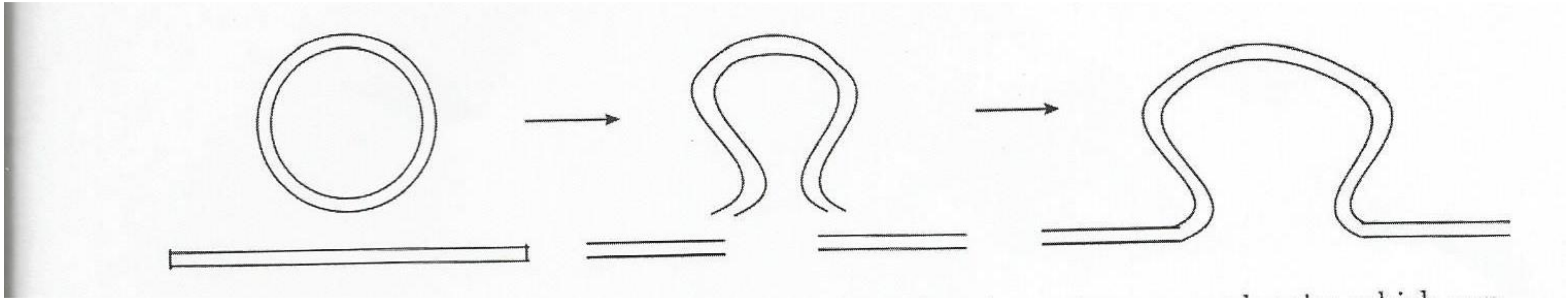


Figure 2: An gluon’ analog of the Harari-Rosner quark duality diagram for the (2,2) process of scattering of two glue-balls ’ ($gb' + gb'$). It clearly shows that $g'g'$ i.e the gb' glue-ball states can be exchanged in both the s and t channels

Greatly exceed the bound of 10^{-24} cm^2. M(DM)/GeV gb's are not DM?
As the universe expands the gb's cool and tend self canibalize via 3→ 2 processes but without entropy dumping into SM or another sector the Co-moving gb' number density deceases moderately. (chm)
We estimate n(gb'). (now) = $4.10^{-3} - 0.5$ cm^2 for Λ' = 1-100 eV so that gb' e density= 0.03 eV – 0.35 KeV #
Recall: ordinary CMB first hinted by "Noise" in the of P&W. What noise the barrage of the Cgb'B generate in our Quirky communication line?
Enroute each string bit of size λ suffers many collisions:
N(col) =λ*d' Φ(gb').L/c where d' = 1/(Λ') is the string thickness But the excitation of the carrier mode of interest w(0) = c/(λ) by the short plucking of duration d'/v' is suppressed by w(0).d'/v' and only $(w(0)d'/v')^2$ of the collision energy m(gb').v'^2 namely m(gb')$(w(0)d')^2$

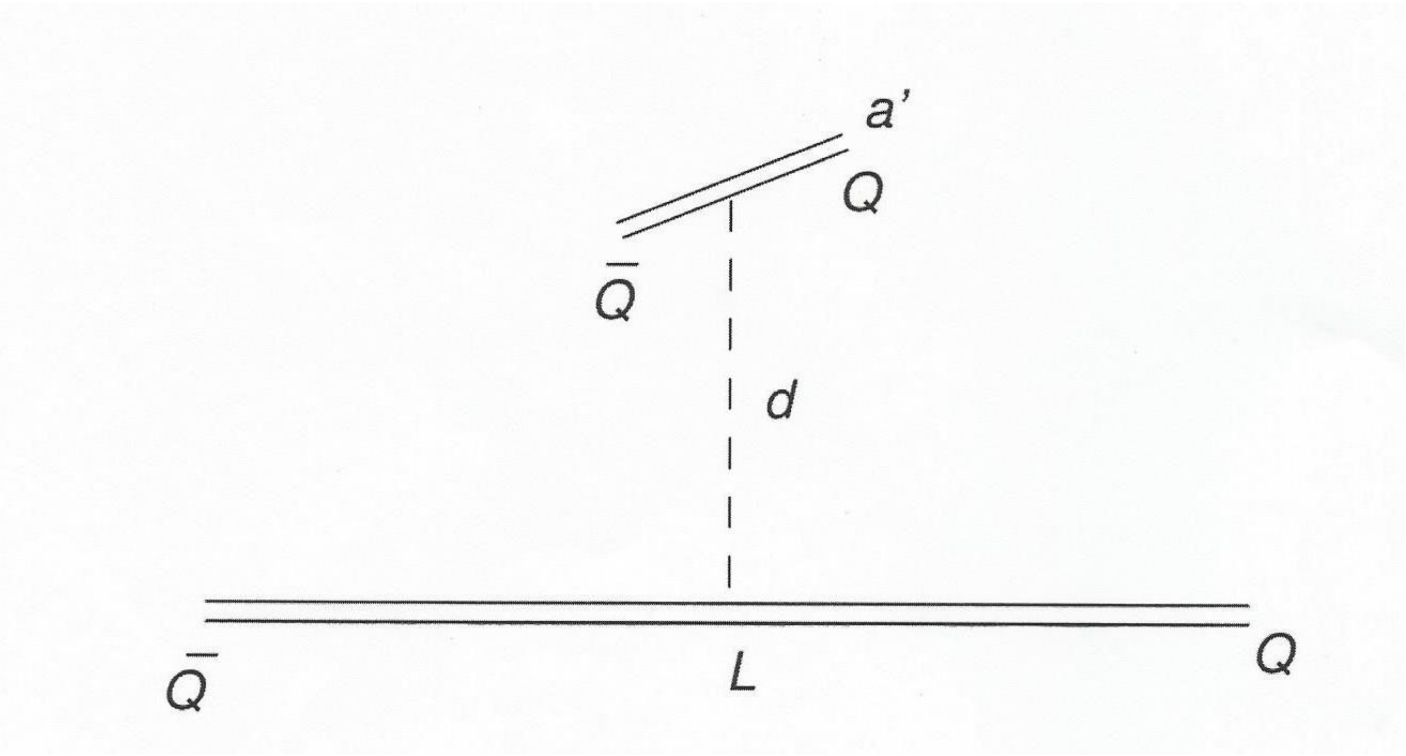
Is transferred in each collision . We find that the total energy transferred t
the traveling string bit is smaller than the kinetic energy initially imparted
to it = $E(i)=\lambda\Lambda'^2 . v(in)^2$ with $v(in)= c(sound) \sim 10^{-5}$.

If the gb's behave as small closed strings then their sticking to the long co
string (with $\Delta(E) = m(gb') c^2$) is TOPOLOGICALLY suppressed as:



alternatively the string heats up to the "temperature" of the gb'
$T'= m(gb') v'^2$. Transferring a bit of info requires energy of T' but
$E(i)$ much exceeds it .

CR's produce in the ISM Q' Q' ==> Rouge Yo-yoing strings can cut ours!



σ (Ss) = L. d(tp) = $10^{21}*10^{4} = 10^{25}$ cm^2 is HUGE. But mfp for pp collision is 10^{25} cm Rouge string travel only ~ 10^{11} cm before Q'Q' annihilate ➔only the last 10^{-14} fraction is effective!

$\Phi(CR)$ | E> $W(LHC)^2)/GeV \sim 10^{-11}$

BR (pp➔ Q' Q') ~ 10^{-13}

Jointly- cutting is suppressed by $10^{(14+11+13)}$ making even very long K parsec Com lines safe for very long times.

Final Comment – By releasing the Q'Q' at vey latge distances we can have them collide at arbitrarily high energies

$W = 4\Lambda'^2 . L = 10^{21}$ GeV >> M(Planck)