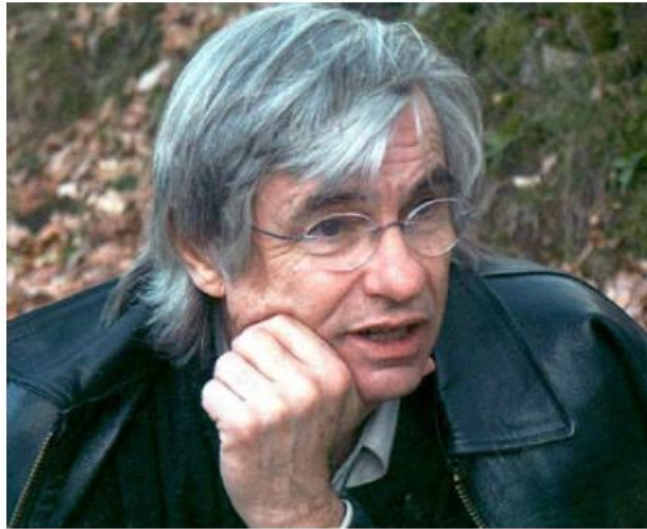


Ubumenyi butagira Imipaka

Itegeko ryo mu 1901 rigenga amashyirahamwe



Jean-Pierre Petit, Perezida w'iri Shirahamwe

Uyu Jean-Pierre Petit, Peresida w'iri shyirahamwe ry'Ubumenyi butagira Imipaka, yahoze ari diregiteri w'ubushakashatsi mu kigo cy'inzobere cya CNRS, mu Bufaransa. Akaba kandi inzobere ihanitse muri Fizike y'inyenyeri (Asitorofizike); yahimbye uburyo bushyashya by'inyandiko bita: *Ibitabo by'amashusho by'ubumenyi*. “Ubumenyi butagira Imipaka” ni ishyirahamwe ryahimbwe mu 2005 n'abagabo babiri, Jean-Pierre Petit na mugenzi we Gilles d'Agostini. Iri shyirahamwe ryihaye intego yo gukwirakwiza kw'isi hose ubumenyi ku buntu harimwo n'ubumenyi bwa tekhnike, ubukorikori n'ikoranabuhanga. Iri shyirahamwe ribeshejweho n'inkunga rihabwa. Izo nkunga nizo ziriha abantu bahindura inyandiko mu zindi ndimi. Buri nyandiko (igitabo cy'amashusho cy'ubumenyi) ihindurirwa mu rundi rurimi ku mafaranga angana n'amayero 150 (150 euros) kuva mu 2007 kugeza ubu. Iri shyirahamwe rinariha amafaranga ajyanye n'iyoherezwa ucishije muri banke ry'ayo mafaranga y'ihinduranya mu zindi ndimi. Abahinduranyi b'indimi bagiye bongera, buri munsu, umubare w'ibyo bitabo bisomwa hose k'ubuntu. (Nko kugeza mu 2007, hari hamaze kuboneka ibitabo magana abiri (200) bikurwa kuri interineti k'ubuntu kandi byanditse mu ndimi makumyabiri n'umunani (28) harimwo ikinyarwanda n'ururimi rwo muri Lawosi).

Biremewe ko iki gitabo gikopororwa cyangwa gifotorwa, cyose cyangwa igice; kinakoreshwa n'abarimu mu masomo ariko mu buryo butari ububanza inyungu z'amafaranga. Gishobora gushyirwa mu masomero y'uturere, y'amashuri cyangwa ya za kaminuza, cyanditse ku mpapuro cyangwa cya shyizwe mu miyoboro y'imbuga z'ikoranabuhanga zigose (intranet).

Uyu mwanditsi w'ibi bitabo yatangiye kwandika ibindi byo byoroshye kandi bigenewe abana bato (bari mu rugero rw'imyaka 12). Ibindi biriho bikorwa n'ibitabo by'amajwi avuga, bigenewe abatazi gusoma cyangwa abashaka kwiga urundi rurimi rutari urwo bakuriyemwo.

Iri shyirahamwe rishaka buri gihe abahinduranyi b'inyandiko bazishyira mu ndimi zabo zakavukire ariko bafite ubuhanga buhagije bwo gutanga inyandiko mpiduranyi nziza z'ibitabo basomye.

Ushatse kugira icyo ubaza cyangwa ugeze kuri iri shyirahamwe, wajya ku rubuga rwaryo ku interinete aha hakurikira: <http://www.savoir-sans-frontieres.com>

Iranga-konti mu Bufaransa → Inyandiko ngaragaza mutungo muri (RIB)

Ikigo	Umwanya wo kwakiriramo amafaranga	Nimero ya konti	Urufunguzo rwa RIB
20041	01008	1822226V029	88

Aho ikorerera: Banki ya Posita
Hagati y'Umujyi wa Marseille
13900 Marseille CEDEX 20
Mu Bufaransa

Mu bindi bihugu → Ibanki Mpuzamahanga (International Bank) Nimero ya Konti (IBAN):

IBAN
FR 16 20041 01008 1822226V029 88

→ N' Inyandikobanga ya banki (BIC) :

BIC
PSSTFRPPMAR

Amategako agenga iri shyirahamwe agaragara ku rubuga rwa yo kuri interineti. Imibare ngaragaza mutungo nayo irahari kandi ihora ishyirwa ku gihe. Iri shyirahamwe nta mafaranga na make rikura ku nkunga rihawe uretse ayo kohereza, bicishijwe muri banki, ahemba abahinduranyi b'indimi ku buryo babona abagenewe yose. Nta munyamuryango w'iri shyirahamwe n'umwe rihemba kuko bose ari abakoranabushake.

Abanyamuryango ubwabo nibo barihira amafaranga ishyirahamwe rikoresha ngo ribeho nk'ayo kwishyura no gukoresha urubuga rwa yo rwo kuri interineti kuko ayo atarihwa n'ishyirahamwe.

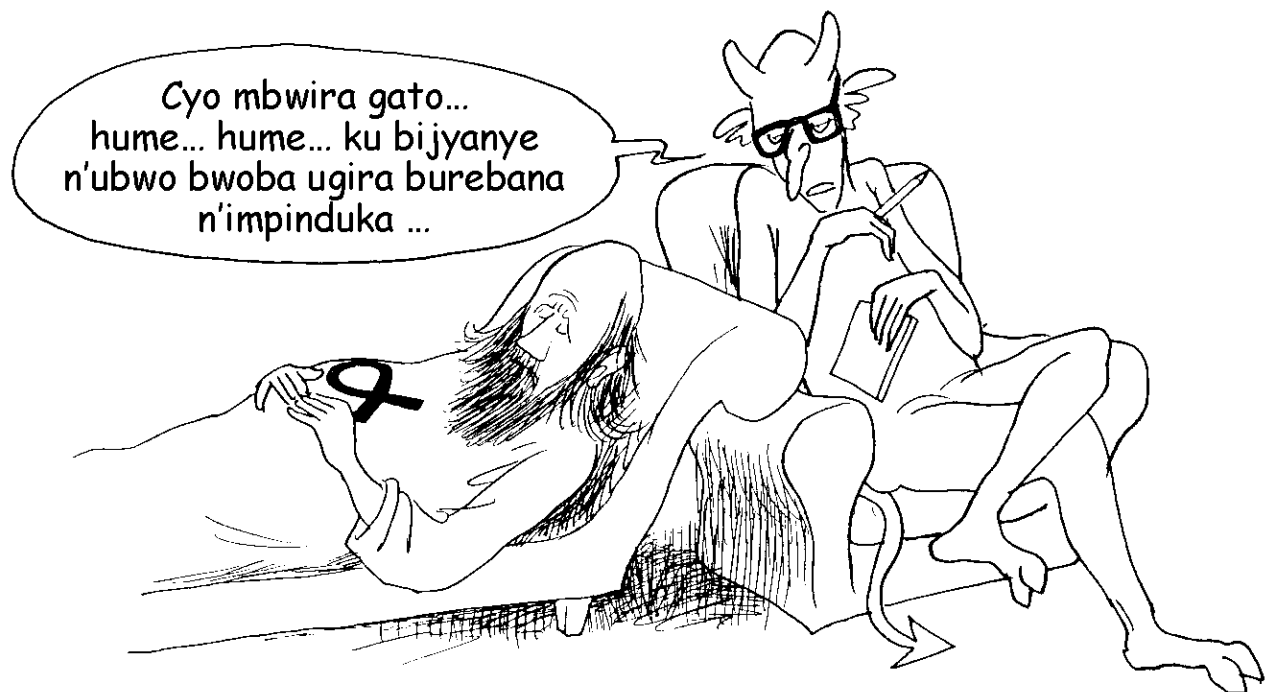
Bityo mugaragarizwa neza uko umutungo w'ishyirahamwe ukoreshwa kandi mukibonera ikizere ko, muri iyo "mirimo y'ubwitange mfashamuco", inkunga yose mutanga ikoreshwa neza mu kwishyura abahindura ibitabo mu zindi ndimi.

Dushyira ku rubuga rwa interineti buri kwezi, ugereranije, nk'ibitabo cumi bihinduwe mu zindi ndimi.

Ubumenyi butagira Imipaka

Bigi Bange

Johani-Petero Petit



Byahinduwe na :
Mohamed Abdel aziz Kamanzi

<http://www.savoir-sans-frontieres.com>

INKOMOKO Y'INKURU

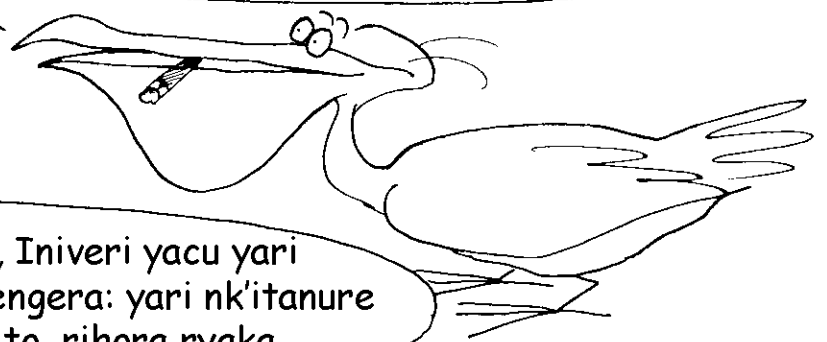


Urabizi, Sofi, kenshi njya nibaza aho ibintu byose bituruka, uko Iniveri yaremwe,

Ese IBINTU BYOSE byahozeho nk'uku bimeze ubu ? isi, ijuru ?

Ese ijuru ryahoze, igihe cyose, risa n'ubururu ?

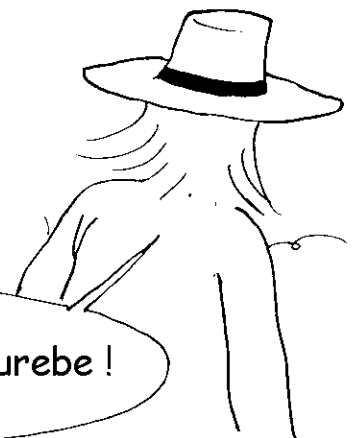
Ese inyenyeri zahozeho igihe cyose zicanye; inyuma ya zo hagaragara ijuru ryijimye ry'umukara ?



Kw'ITANGIRIRO RYA BYOSE, Iniveri yacu yari nto cyane kandi ishyushye by'umurengera: yari nk'itanure rito, rihora ryaka.

Hanyuma rero, nimwe byose biraturika ?

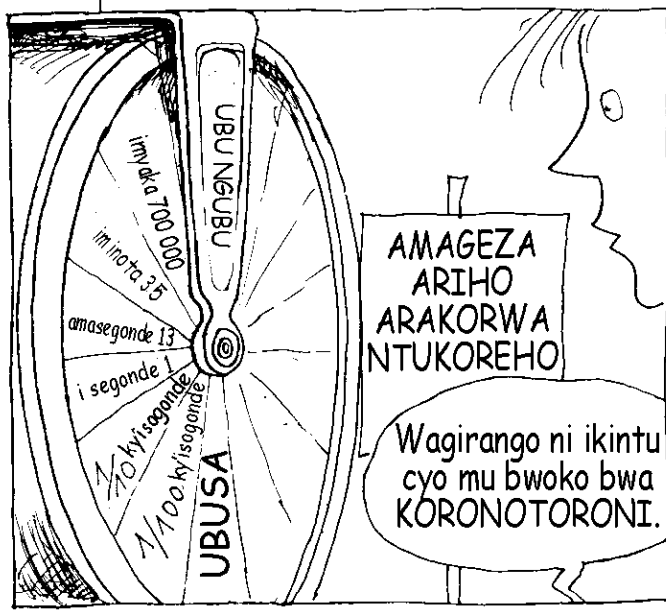
Yego, ariko ni inkuru ndende cyane, kandi kugirango umuntu ayiganire ho, bisaba gusubira inyuma cyane, inyuma cyane pe.



Ohu, nimuze murebe !



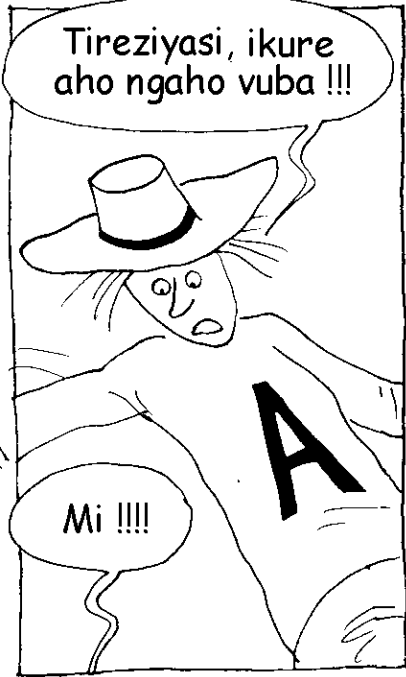
Ariko se icyo kiburagasani ni kintu nyabaki ?



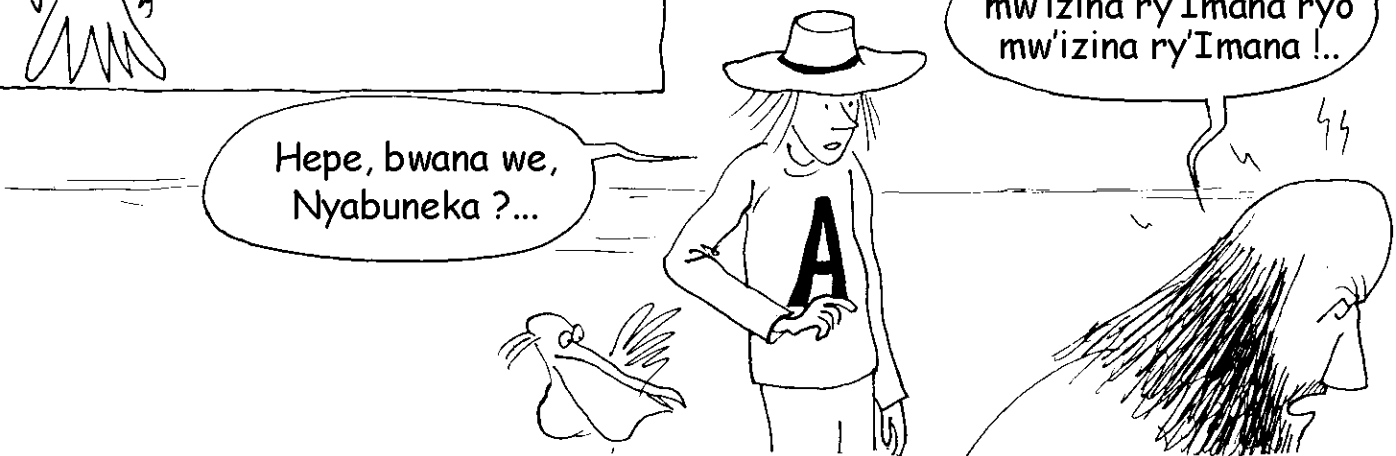
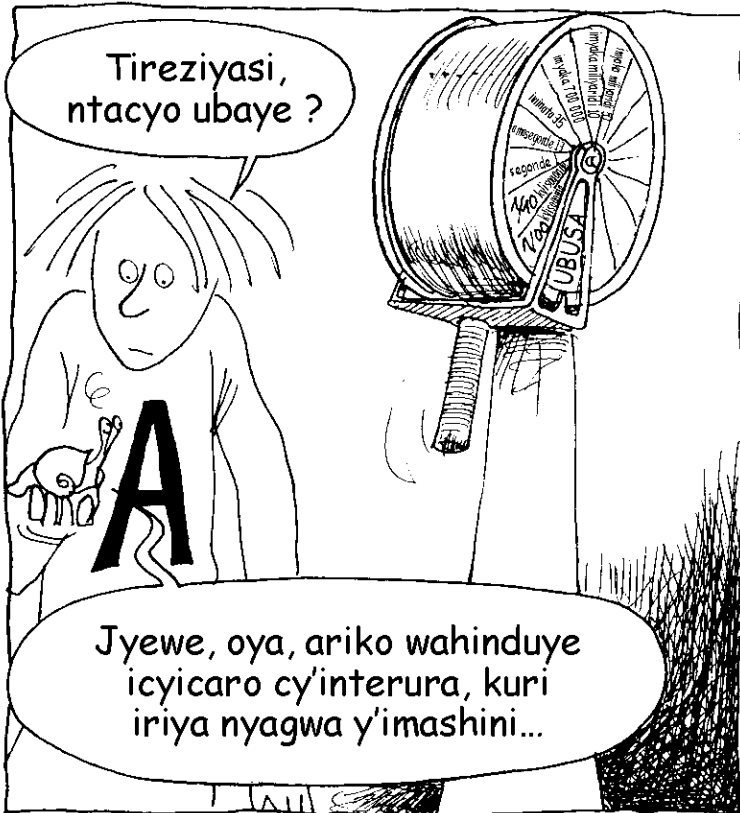
Ziriya ndasago... ntimubonako ziteye amakyinga ?



AKO KANYA...



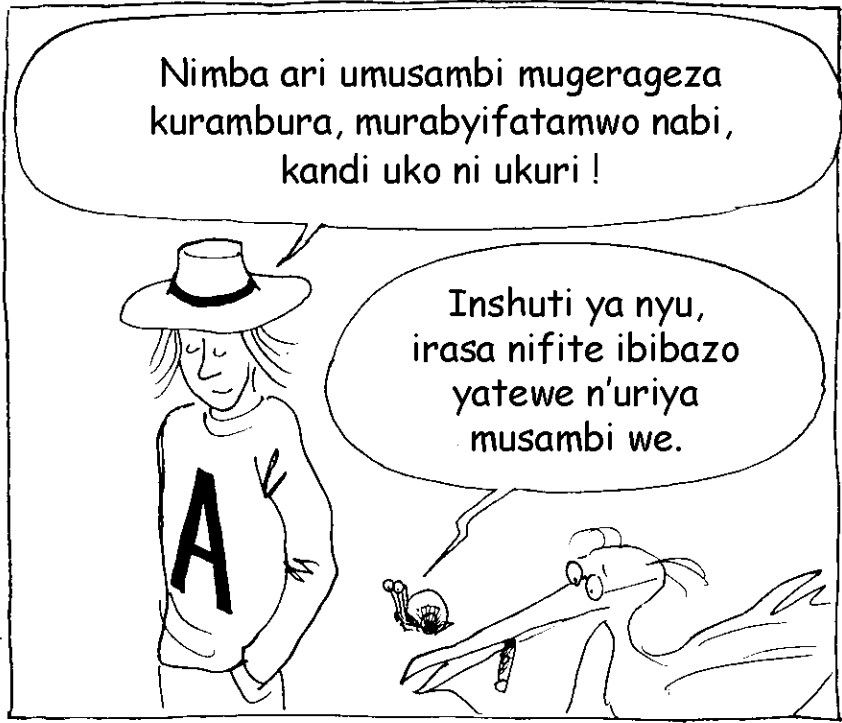
ITANGIRIRO RYA BYOSE





Ngu ko, byanze kandi !

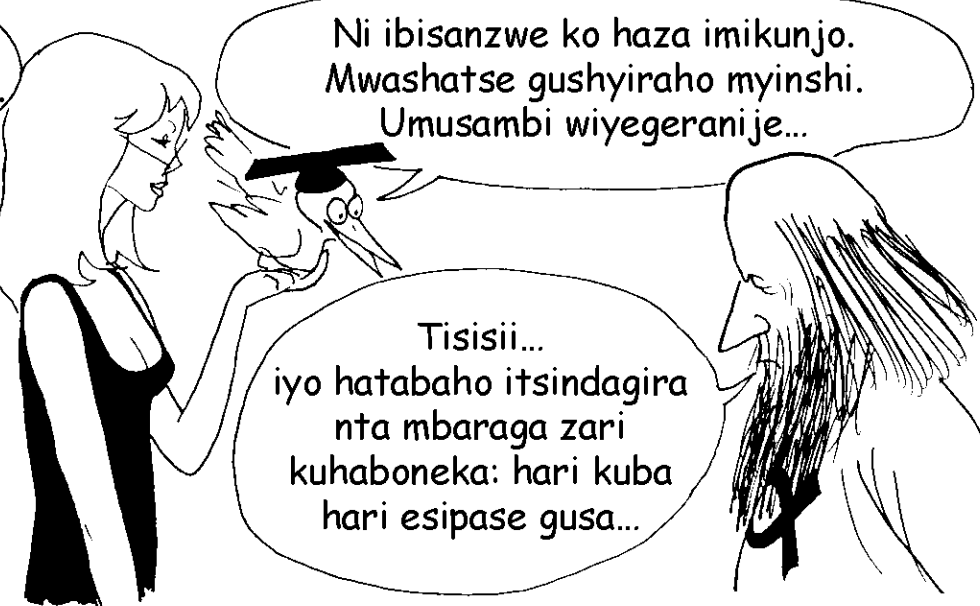
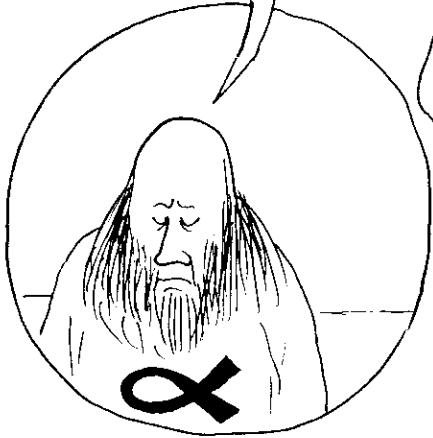
Nishyize mu kagozi...



Nimba ari umusambi mugerageza kurambura, murabyifatamwo nabi, kandi uko ni ukuri !

Inshuti ya nyu, irasa nifite ibibazo yatewe n'uriya musambi we.

Mbega amakuba... imikunjo ahantu hose !..



Ni ibisanzwe ko haza imikunjo. Mwashatse gushyiraho myinshi. Umusambi wiyegegeranije...

Tisisii... iyo hatabaho itsindagira nta mbaraga zari kuhaboneka: hari kuba hari esipase gusa...



Iyaba byari bitsindagiye kimwe hose ! ariko hari ahari amatsinda y'imikunjo, abungera uko yishakiye hirya no hino ntagahunda, k'umuvuduko wa kilometero ibihumbi magana atatu kw'isegonde.

Ibyo ni kwantikye... ni nk'idayimoni rya kwantikye...



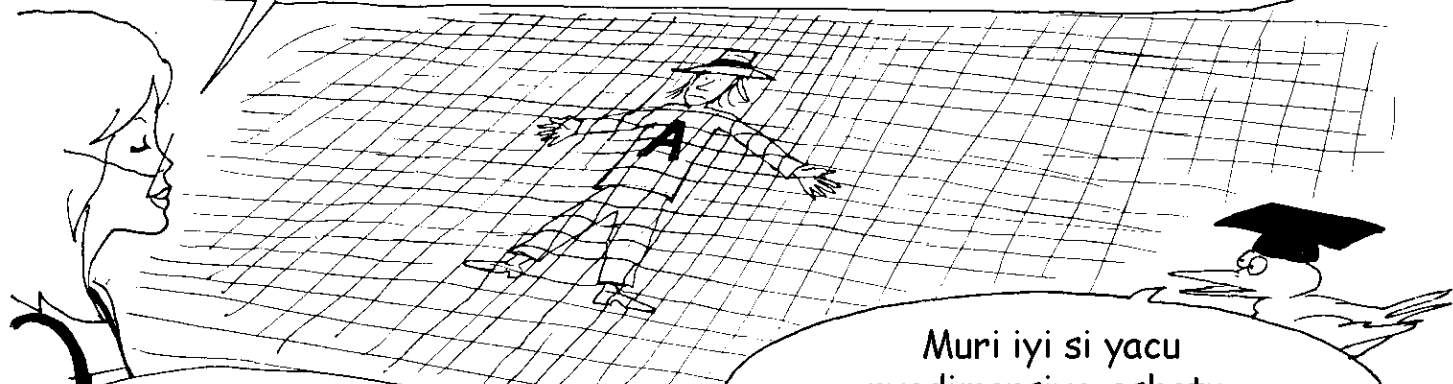
Ni iki ?..



Nta KINTU gikomeye
muri iriya iniveri !

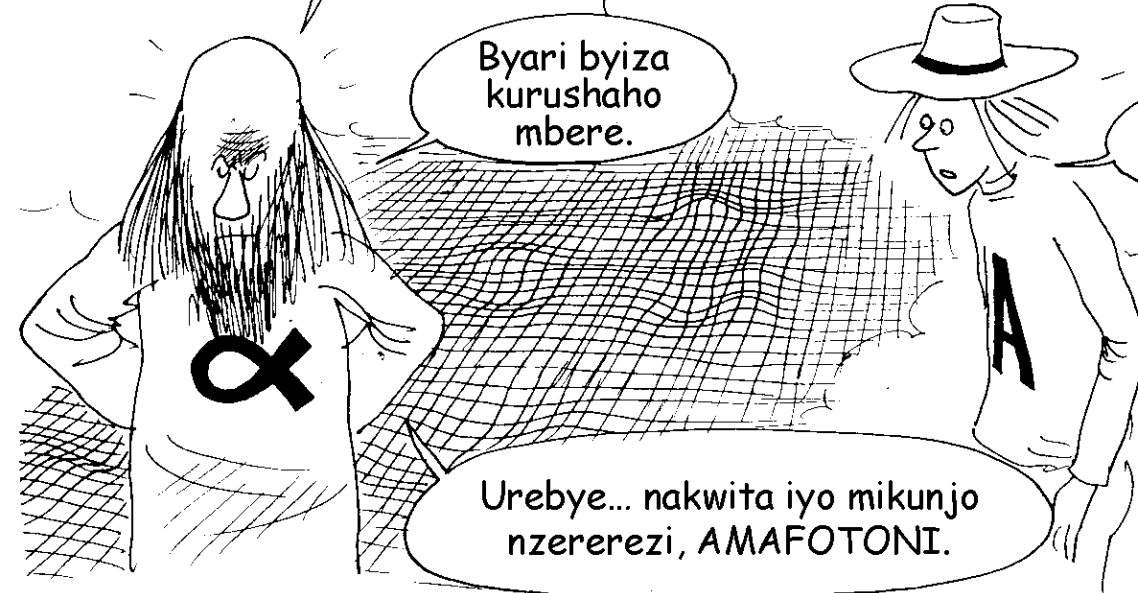
Yego ariko !
Hano ibintu bihari
ni bwa bwoko bw'
imihiro ibungera.

Iniveri yerekanwe hano ifite gusa
dimansiyo ebyiri, ubwo rero ni IKIBYATARARE cy'amabondo yerekana
amaparitikile, amamase, umurasire. Iyaba wabaga muri iyi Iniveri
nyadimansiyo ebyiri, dore uko wari kuba usa.



Ntabwo ari byiza,
ntabwo ari byiza na gato...

Muri iyi si yacu
nyadimansiyo-eshatu,
amaparitikile ni kandi amahinduranya
y'ubuhetame bw'aho ngaho.



Byari byiza
kurushaho
mbere.

Mbere y'iki !?

Urebye... nakwita iyo mikunjo
nzererezi, AMAFOTONI.

Ahaa, mw'izina ry'Imana
ryo mw'izina ry'Imana!
Dore ikindi kintu noneho ubu...

Iki ?

Ariko reba kiriya !
Biri hose !!!

Ntanubwo gusa bizunga bisubira
inyuma, ahubwo biranzungurutsa.
Ni umurimo mwiza !

Wagirango ni twa serwakira duto.
Ni nk'iyo ukoze gurtya mw'ishuka
yo k'uburiri.

Biteye amatsiko, hari utuzenguruka
dukurikiye inzira imwe, kandi hari
n'utundi tuzenguruka ndukurikiye
indi nzira inyuranye n'iyambere.

Ni nka yamafotoni yanyu, tugendera
k'umuvuduko wa $300\,000 / s$.

Nzita utwo twa serwakira
nzererezi NETIRINO, igihe tuzaba
tuzenguruka dukurikiye iyi
nzira:

Kandi izizenguruka zikurikiye inzira ibusani
je n'iyambere nzazita
ANTINETIRINO.

By'ukuri turitingisa pe.
K'umusambi wanyu, nta nahamwe
habyataraye. Imikunjo rwose
iregeranye imwe ku yindi (*)

Iyi Iniveri nta
cyicaro kiri hamwe ifite,
ntiyicaye hamwe na busa.
Yarapfubye rwose !..

Iyaba byibuze, ibyo byose byari bipanze neza kuri gahunda.
Ariko byose bigiye biri hirya no hino, wagirango ni mu buriri
bw'imbwa. Biranyanyagire nta mupango !

Jye ngira ubwoba
bw'imikino y'akavuyo !

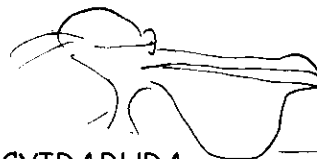
Nshuti ya njye,
akavuyo, ni shitani !

Ahaa...


KOSIMOSOLE,
IKIRINGITI
CYA INIVERI YOSE.

Yewe sinjya
nkina n'akamari...

Ohu, reba ! hari IKINTU
kiriho kiraba hariya...



(*) Imyitwarire y'icyo bita UMURASIRE W'IKINTU CYIRABURA
(satani azi impamvu...)

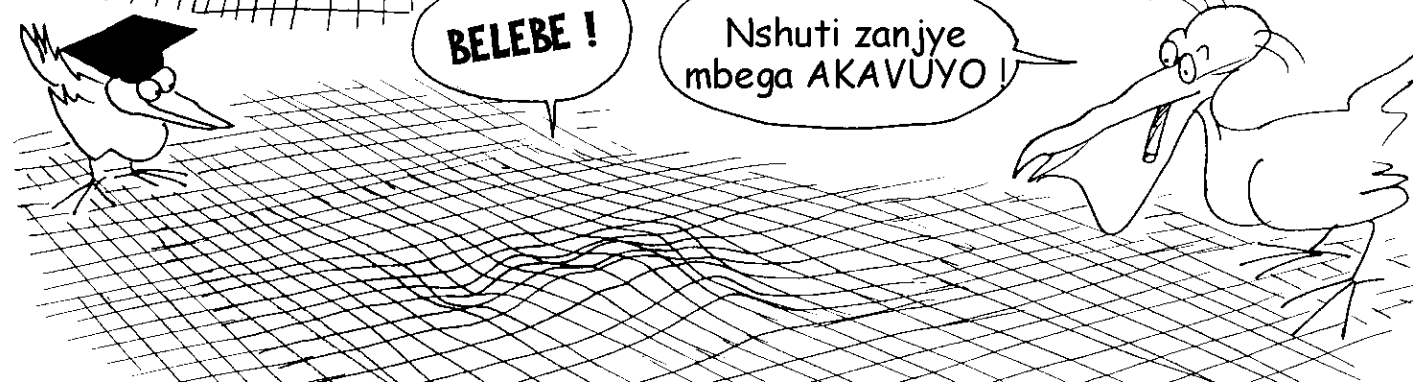


Dore imihiro ibiri y'inzererezi umwe wose igyenda usanga uwundi. Igiye kugongana.




BELEBE !

Nshuti zanjye mbega AKAVUYO !



Ubu biriho birasubira inyuma, kimwe kireba hejuru, ikindi kireba mu nsi.



Kimwe cyose kiritaza ikindi k'umuvuduko ujya kwegera km 300000/segonda.

Byiza. Nzita amapfupfu MATSIYERI,
naho ibifukuye INDWANYAMATSIYERI.
Hariho u BUHETAME, ni ukuvuga MASE.

Fotoni yo irafukuye
kandi ni ipfupfu, ubwo
rero ni paritikile ubwayo kandi
ikongera ikaba indwanyaparitikile
yayo bwite.

MATSIYERI n' INDWANYAMATSIYERI,
byaturutse mw'isekurana ry'amafotoni,
bigaragarana imivuduko nyarolativate.

ipfupfu, imfukure,
ibyo byose ni ibyitiriro.

Nshuti yanjye Tirezziyasi,
ni ikihe gisobanuro cy'icyo
gitekerezo kirekire ?
Hari ibintu bigaragara
nk'imfukure n'ibindi
nk'amapfupfu. Ibyo bibonwa
na buri wese...

Ni uko turi kuri uru ruhande rw'umusambi. Iyo tuza kuba turi
k'urundi ruhande, amapfupfu yahinduka imfukure; naho imfukure
zigahinduka amapfupfu.

Ariko... jye ndabona
uruhande rumwe gusa !!!

Tirezziyasi !!!

Nta buryo na bucyeye
bwo guseka bugihari...

?...

Dore kandi umupolisi
w'ubumenyi(*)

Buretse ! Hariya ... iyo ipfupfu n'imfukure bihuye bigenda buhoro cyane,
bitanga imihiro ibiri nzererezi. Ni igikorwa ncurikaburyo.

Humu... IYONGA risanzwe
rya paritikile ya matsiyeri
na ndwanyaparitikile ya yo.
Ibyo bitanga ftoni ebyiri.

Ako ni AKAVUYO
ko muri kosimosi

Humuu...

(*) umucunzi wa Episitemoloji: Episitemoloji: imyigire k'ubumenyi Umucunzi w'ubumenyi.


Ikorwa n'isenywa ry'amaparitikile, uhereye kw'itsinda nyabibiri ry'amafotoni, bikurikirana ku karindi kihuse. Muri iyi si y'akavuyo, iyi si y'impinduka, nta mitererempagaze ibamwo. Gusa habamwo inyuranamwo rya cyane rya za fotoni, rya za netirino, rya za ndwanyanetirino, hamwe na paritikile na ndwanyaparitikile byinshi, z'umuvuduko mwinshi n'uburambe bw'igihe gito cyane, kandi zinyuranye. Ni AKAVUYO (*)



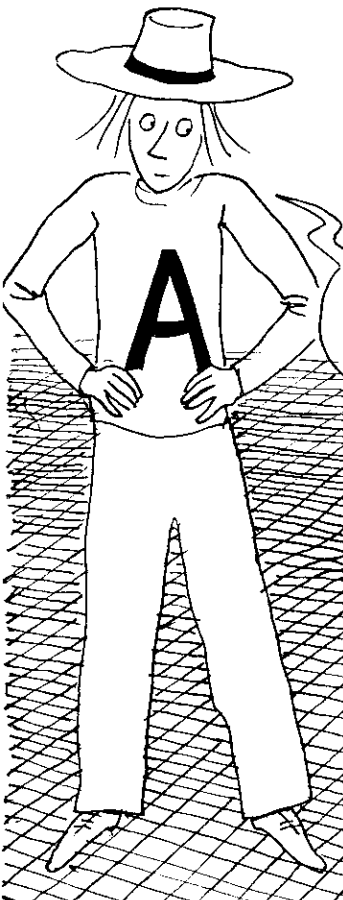
Jye bintera gutekereza kuri za SEGISONI



SEGISONI ni iki ?



Ni paritikile zimara umwanya wazo wose zibyaragura.



Uko tubibona, hari imikunjo nzererezi y'ubugari bunyuranye cyane, nk'uko hari amapfupfu mato kandi maremare n'andi yagutse kandi abyataraye.

Nzita λ , UBUREBURE BWA ONDE naho indeshyo y'imikunjo nzererezi, ama FOTONI

Reka dutekereze ko nkoze umuhiro nzererezi igihe nyeganyeye uyu muguzi. Ubwambere ndawuzunguza buhoro, nkoreshyeje imbaraga nkye noneho ubwo uburebure bwa onde λ buba burebure.

Ubu noneho reka nyeganyeze cyane uyu muguzi, ni nongera IMBARAGA ziwunye ganyeze, uburebure bwa λ buzaba buguvi pe ugereraniye n'ubwambere.

Ye!

K'uburyo rero, uko onde ijyenda itwaye imbaraga ni nako uburebure bwa yo buba bugufi.

Nzavuga ko imbaraga zitwawe na FOTONI, akamanyu k'URUMURI, zizajyenda zihinduka MU NCURIKABURYO ugereraniye n'UBUREBURE BWA ONDE λ : E ihinduka bu burtyo bumwe na $1/\lambda$

Birtyo, bizakunda ...

UKO BIHA BITO NI NAKO BIREMERA CYANE



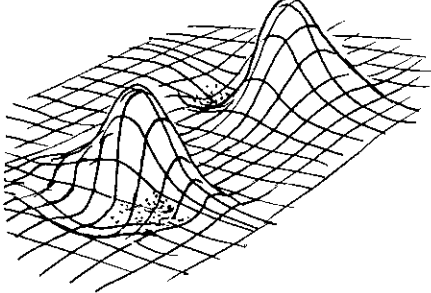
Yego ndabyemeye kuri iriya mikunjo nzererezi mwita FOTONI. Ariko se ni iki gitandukanya imfukure cyangwa amapfupfu byegeranye kandi birebire n'imfukure cyangwa amapfupfu byagutse kandi bibyataraye ?

Ngiye kwita buriya bwaguke bw'imfukure n'amapfupfu UBUREBURE BWA ONDE YA COMPTON λ_c ; MASE m yo, izahinduka ariko ikurikiye inzira NCURIKABURYO. Ni nko kuvuga ngo izahinduka mu buryo bumwe na $1/\lambda_c$.

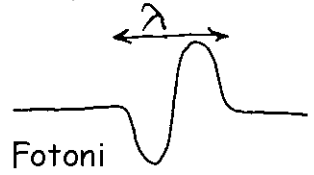
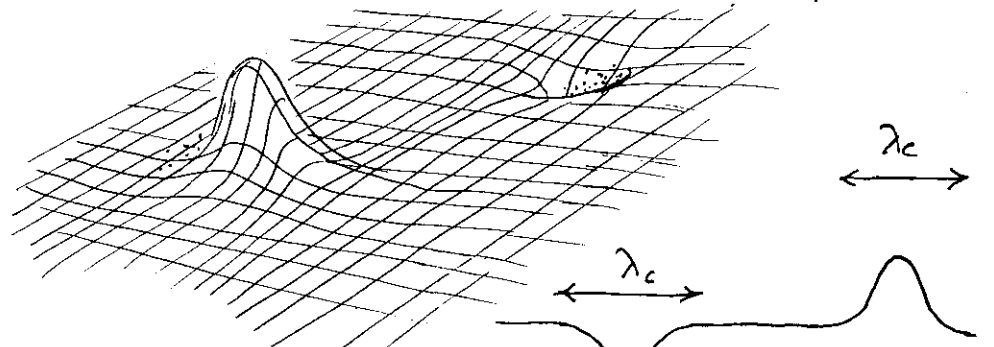


Fotoni z'imbaraga nyinshi, z'uburebure bwa onde bugufi, zizabyara amaparitikile (hamwe na ndwanyaparitikile) za mase m nini cyane, yegeranye kandi ndende.

λ nto



λ_c nto : uburebure bwa onde ya Compton bugufi;

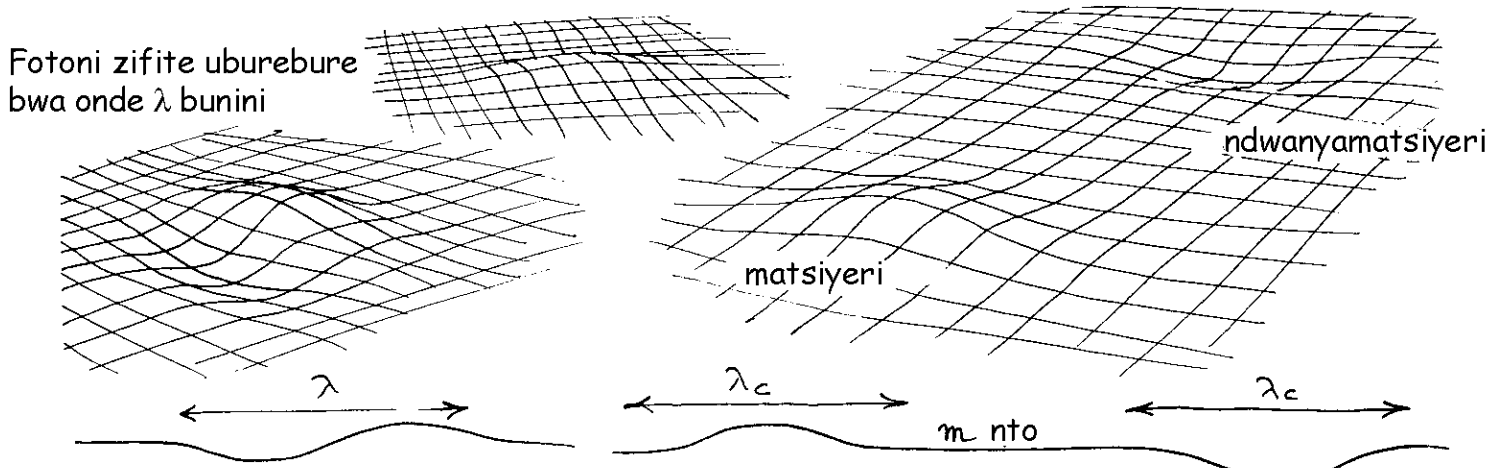


Fotoni

mase m nini

ndwanyamatsiyeri

matsiyeri



Fotoni zifite uburebure bwa onde bunini \rightarrow paritikile zifite uburebure bwa onde ya Compton bunini.

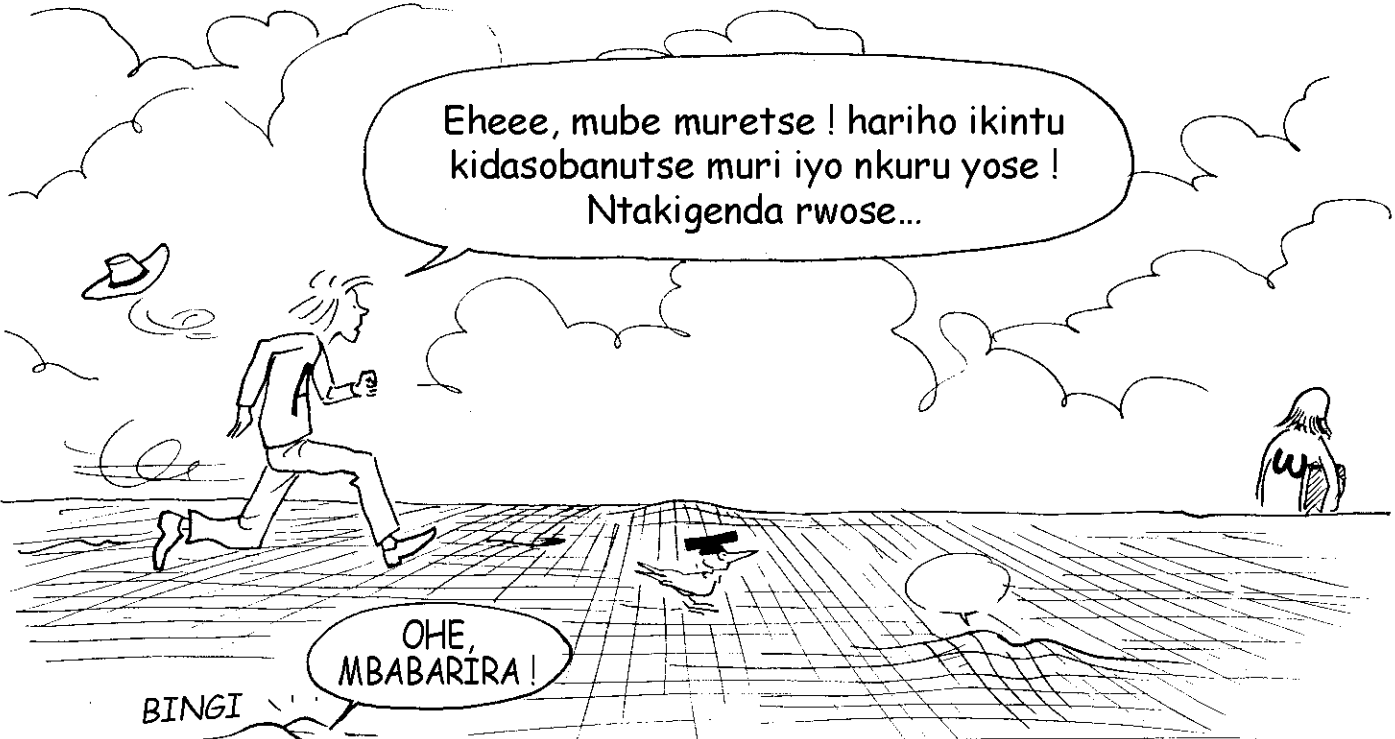
Dukurikije incurikaburyo, fotoni ugereraniye z'ingufu nkye, zizabyara itsinda nyabubiri paritikile-ndwanyaparitikile zifite uburebure bwa onde bunini, ni ukuvuga bifite mase nto: λ_c nini, m nto.

Mu bigaragara, ni ibintu ubundi byoroshye cyane. Nkurikije uko mbibona $\lambda = \lambda_c$ (*), ni ukuvuga ko za paritikile (na ndwanyaparitikile) zifite uburebure bumwe nka za fotoni zizibyara.

Ni ukuvuga ko iyo uzi MASE ya paritikile iyariyo yose, umenya neza ako kanya uburebure bwa onde y'umurasire wa yibyaye.



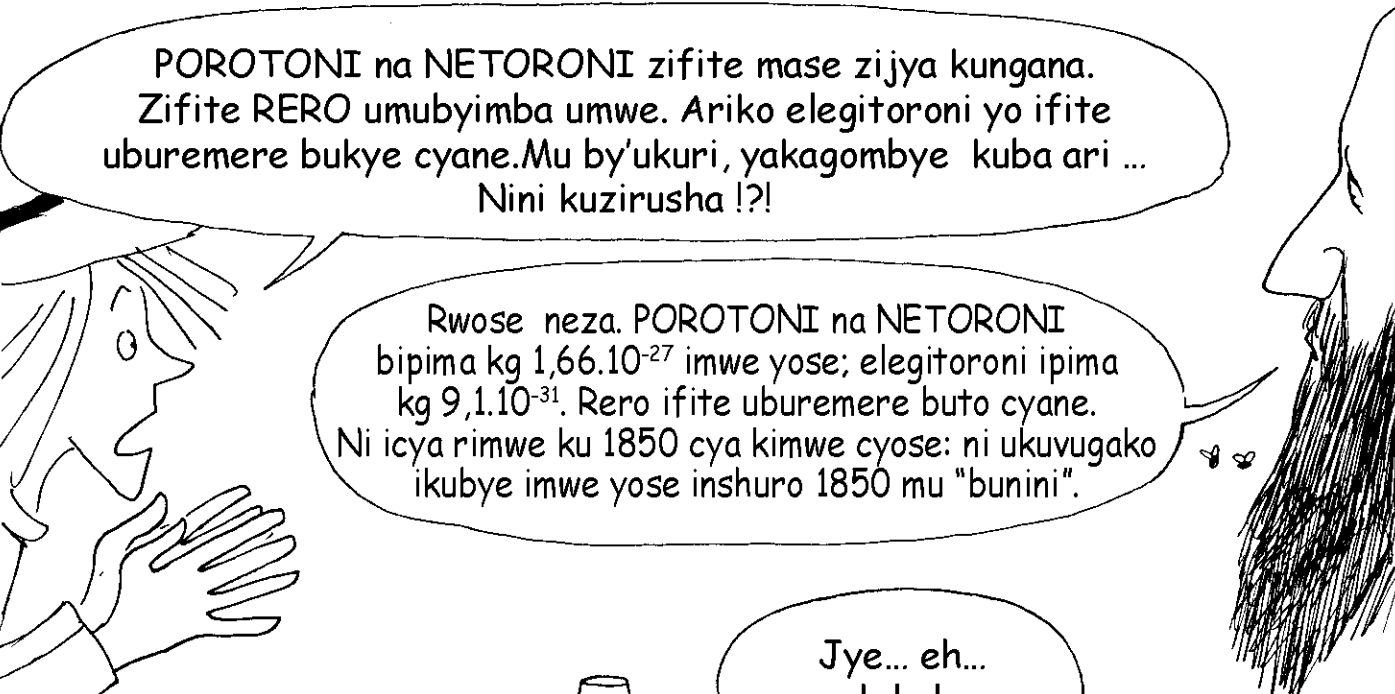
(*) twibuke ko $E(\text{ingufu}) = m(\text{mase})$. Reba BYOSE BIFITANYE ISONO.



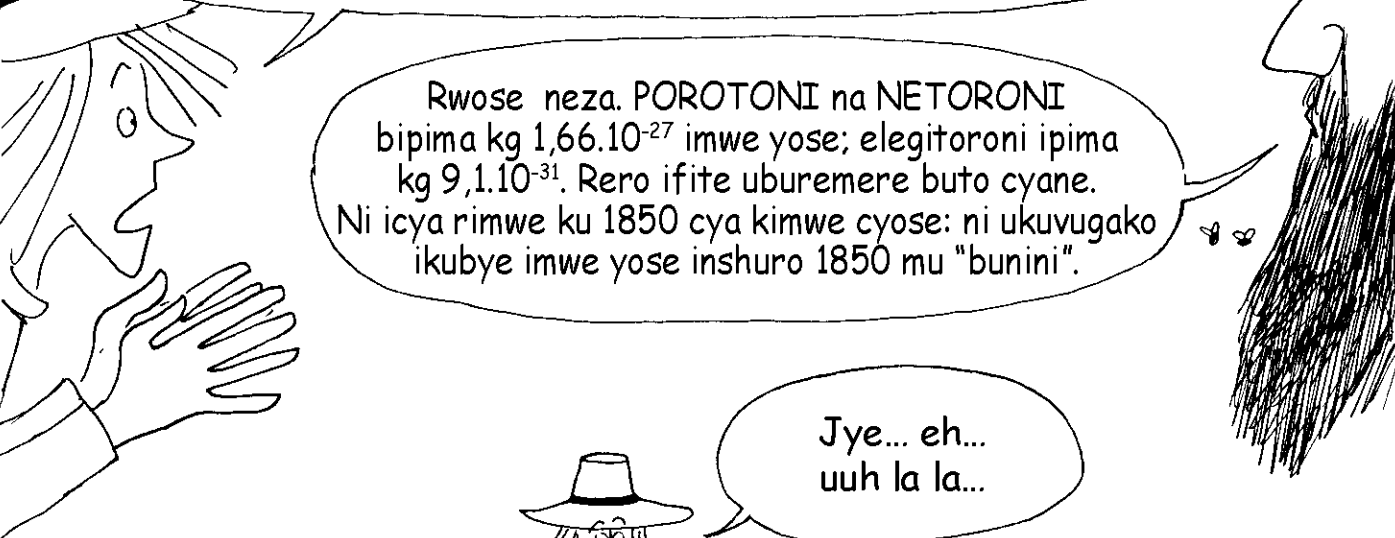
Eheee, mube muretse ! hariho ikintu kidasobanutse muri iyo nkuru yose ! Ntakigenda rwose...

OHE, MBABARIRA !


BINGI



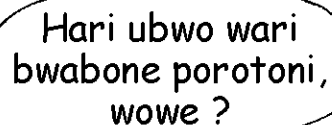
POROTONI na NETORONI zifite mase zijya kungana. Zifite RERO umubyimba umwe. Ariko elegitoroni yo ifite uburemere bukye cyane. Mu by'ukuri, yakagombye kuba ari ... Nini kuzirusha !?!



Rwose neza. POROTONI na NETORONI bipima $kg\ 1,66 \cdot 10^{-27}$ imwe yose; elegitoroni ipima $kg\ 9,1 \cdot 10^{-31}$. Rero ifite uburemere buto cyane. Ni icya rimwe ku 1850 cya kimwe cyose: ni ukuvugako ikubye imwe yose inshuro 1850 mu "bunini".



Jye... eh... uuh la la...



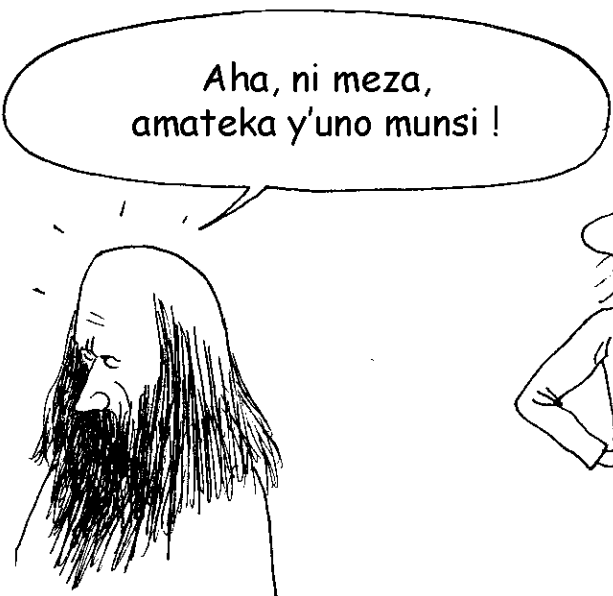
Hari ubwo wari bwabone porotoni, wowe ?




Ehi... OYA...



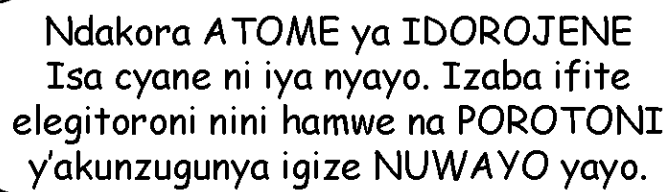
Nonese !



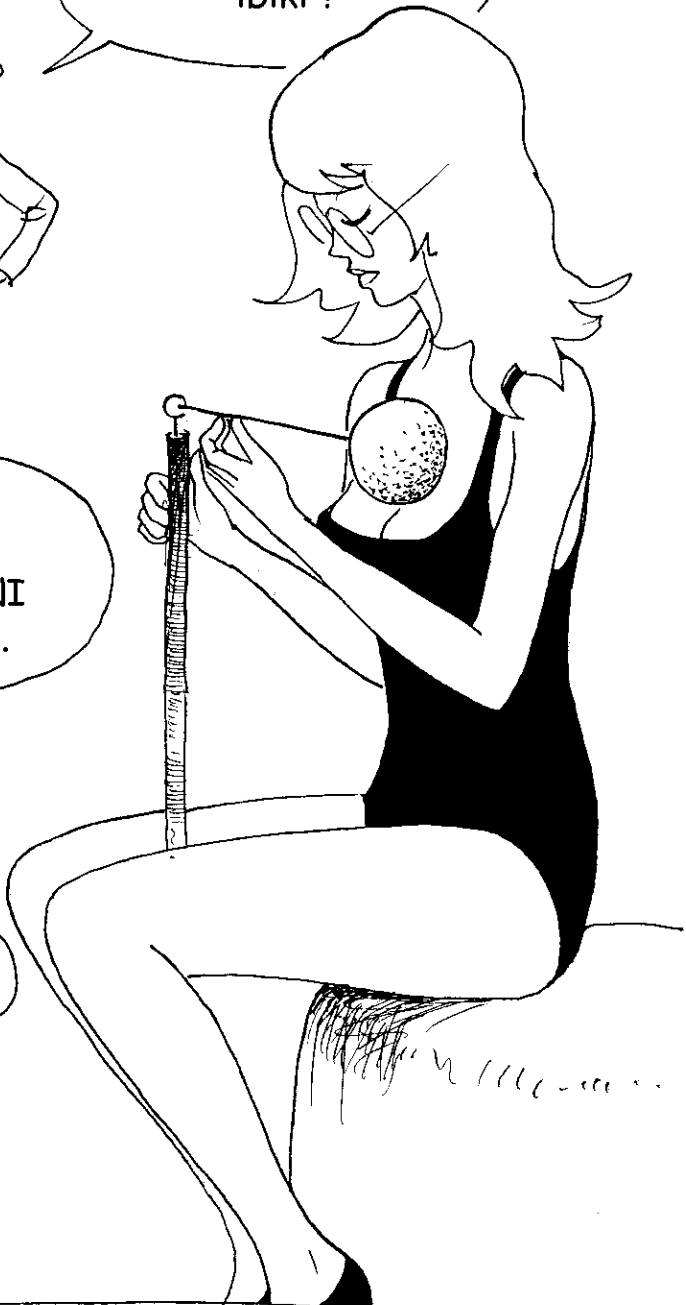
Aha, ni meza,
amateka y'uno munsu !



Urakora
ibiki ?



Ndakora ATOME ya IDOROJENE
Isa cyane ni iya nyayo. Izaba ifite
elegitoroni nini hamwe na POROTONI
y'akunzugunya igize NUWAYO yayo.



Kw'Izina ry'Imana ry'Izina ry'Imana !
Mbega akavuyo... ahubwo rero... Bana ba nje,
muramfasha gushyira ku murongo ibi binyagwa.

IGIPIMO CY'UBUSHYUHE BW'UMURASIRE

T_R



Bobobo...

Izi fotoni zose zigiyeye zigira uburebure bwa onde bunyuranye, ingufu zinyuranye. Ariko, kuri iryo tsinda ngiyeye gukoresha uburebure bwa onde bwo hagati na hagati, kimwe n'ingufu nyafotoni zo hagati na hagati.

IGIPIMO CY'UBUSHYUHE BW'UMURASIRE T_R kizaba igipimo cy'ingufu zo hagati na hagati za fotoni.

Mbega amakuba...

IGIHE CY'UBURINGANIRE

Noneho rero, imvange ishobora kugira ibipimo by'ubushyuhe byinshi ?!!?

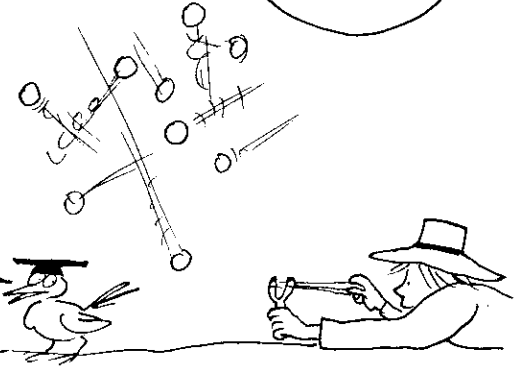
BINGI !

Yego, ariko tuzabibona ibyo byose kuri paje ya 46. Hagati aho, igihe tugitegereje, uduce duhanahana hagati yatwo, ingufu, cyangwa tukazihanahana na fotoni, binyuze mw'igongana. Iyo nzira nyabikorwa isa niringaniza ibipimo by'ubushyuhe, IBINGANISHA, ishyira sisiteme mu gihe CY'UBURINGANIRE NYANGUFUBUSHYUHE.

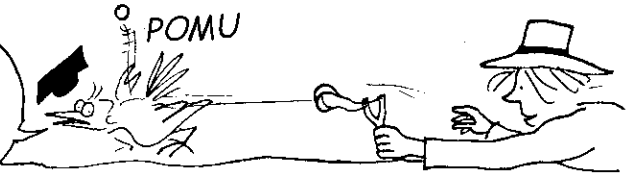
UBUSHYUHE BWA MATSIYERI

T_m

Izo paritikile NYAMATSIYERI zose zifite mase m'umuvuduko V binyuranye. INGUFU NYAMUVUDUKO za paritikile nyamatsiyeri zingana na $\frac{1}{2}MV^2$. Ariko, kuri iryo tsinda, nshobora gusobanura ingufu ry'itingisa (NYABUSHYUHE) ryo hagati na hagati.



Kandi UBUSHYUHE BWA MATSIYERI T_m buzaba igipimo cy'izo NGUFU ZO HAGATI NA HAGATI RY'ITINGISA NYABUSHYUHE.



NYANGUFUBUSHYUHE

Iyo paritikile ifite ingufu nyishi, iyo yihuta cyane, iyo "ishyushye" cyane, isekurana n'iyindi paritikile rigabanya umuvuduko wa yo. Bigenda birtyo no mu ncurikaburyo iyo igyenda buhoro cyane. Niba iyo fenomene yo guhuza ingufu y'ibintu binyuze mwisekurana ari nini cyane bihagiye, si ubushyuhe bwonyine buzaringanira gusa, ahubwo buzaguma bucyo naho wagabanya volime y'iyi vange cyangwa wayikwedura.



Mbega itingisa! Amaparitikile na ndwanyaparitikile bivuka kandi bipfa bimatanye mw'itsinda-nyabubiri, ku umuvuduko w'umurengera.

Ni ibiki bisabwa kugirango itsinda-nyabubiri paritikile-ndwanyaparitikile rikorwe ?

UBUSHYUHE BW'IBANZE

Kugirango hakorwe itsinda-nyabubiri paritikile-ndwanyaparitikile, ya mase rusange m , hagomba ingufu zingana na $2mc^2$, zitanzwe n'itsinda-nyabubiri rya fotoni zifite ingufu z'umurengera cyangwa zingana n'icyo kigero.

Niba ingufu zo hagati na hagati za fotoni ziri mu nsi y'izo ngufu mpagurukiro mc^2 , ni ukuvuga iyo igipimo cy'ubushyuhe bw'umurasire T_R buri hasi cyane (mu nsi y'umubare mpagurukiro) izo paritikire nyamatsiyeri ntiziba zigisubiye gukorwa.

Uwa...

ITERAMBERE RY'UBWOKO BW'IBIBAHU

INKOMEZABUZIMA BW'IKIBAHU ni, buri gihe, impurabibazo. Ishobora kubeshwaho n'umuvuduko w'ubwororoke w'umurengera.



Bisaba ko igipimo cy'ubushyuhe bw'umurasire T_R kigomba kuba kiruta igipimo cy'ubushyuhe mpagurukiro cy'icyo kibaho.

Dore za segisoni !

Niba igipimo cy'ubushyuhe T_R kiri hasi cyane, impamvu nyishi zo kuzimangatana ziba zishobora gutekerezwaho.

Iteye ubwoba ni ihondana-nzimangatanyi na ndwanyaparitikile ya yo.

POLOPE

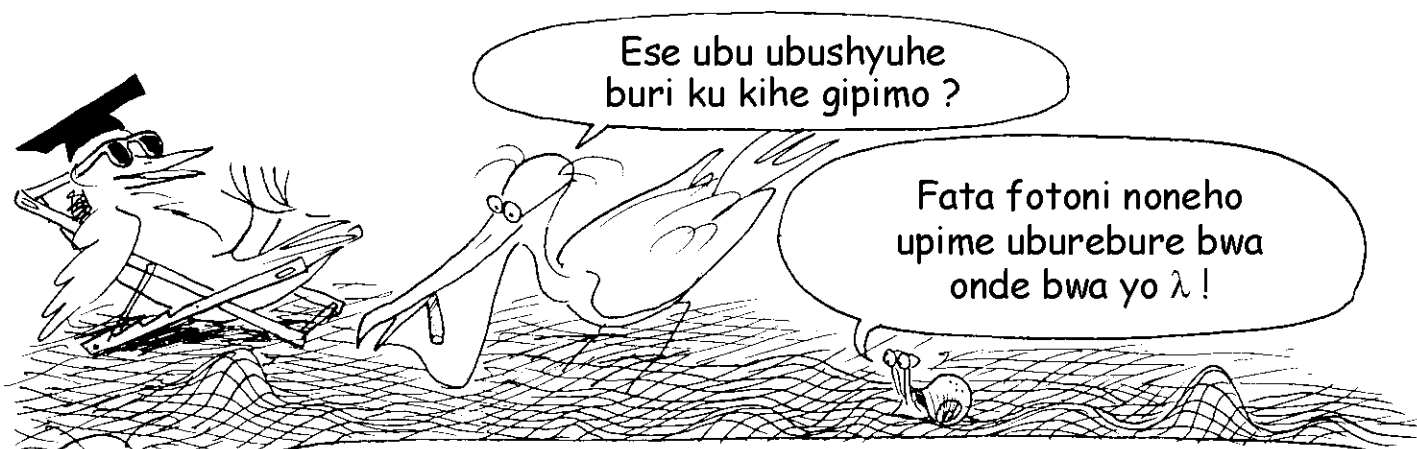
Nyuma y'aho haza amahuriro mabi y'ubwoko bwose.

Kosimosi ni incamuhogo.

Mugusoza mbabwire ko amaparitikile afite UBURAMBE BW'UBUZIMA (*) bwabwo bwite. Icyo gihe iyo kirangiye, ayo maparitikile yihindura ubwayo mu yandi maparitikile akanatanga umurasire.

Ikibazo, ni ukuramba...

(*) ... ikigega cya byo cya KORONOLE.
Reba IBINTU BYOSE BIFITANYE ISANO




Ese ubu ubushyuhe
buri ku kihe gipimo ?

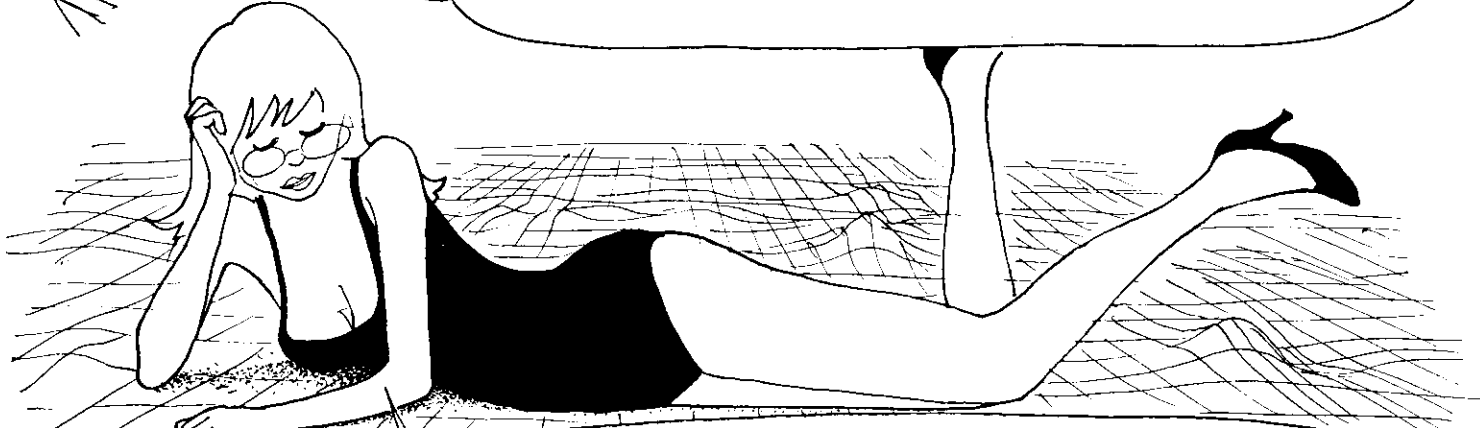
Fata fotoni noneho
upime uburebure bwa
onde bwa yo λ !




Itanure ry'itanure, dogere miliyari ibihumbi makumyabiri (2×10^{13} K)



Bisa naho hari umubare ungana wa fotoni,
wa netirino, wa porotoni, wa netoroni,
wa elegitoro (na za ndwanyaparitikile za zo).



Ku gipimo cy'ubushyuhe bw'umurengera nk'uwo,
buri kintu cyose ni ROLATIVISITE.
N'izo paritikile nyamatsiyeri zigendera ku mivuduko
yegeranye n'umuvuduko w'urumuri c.



Muri IBINTU BYOSE BIFITANYE ISANO, twari twabonye
ko iyo umuvuduko wa paritikile usatira umuvuduko w'urumuri,
IGIHE NYAKURI cya yo gihagarara nk'umufa.



Mu by'ukuri, bizamura ikibazo gikomeye...
iyaba abantu n'ibintu byose byagendaga k'umuvuduko w'urumuri,
ni ukuvuga ko IGIHE (*) kitakongera kugenda ??? nta muntu
n'umwe washobora kuba muri ubwo buzima...

Nta muntu ugenda buhoro
bihagije ngo abone igihe kirekura
m'uburyo busobanutse.



Ohu !..

Isi itagira IGIHE
NA GITO yaba ari nta
BUSOBANURO ifite.

Igihe yenda se, ni ikimenyetso cy'ubukire
buhantse gishobora kubonwa na za Iniveri
zimwe na zimwe ?

Ni akavuyo !

Yewegawe, nkurikije
ibyo maze kubona no kumva...
ESIPASE, IGIHE, INIVERI,
ibyo byose ni agakingamaso.

Ikigize
ibintu byose byo
muri iniveri ?

Agafu ka
Perilimpinipine

(*) igihe nyakosimosi gishobora kuba umwanya wo hagati na hagati w'IBIHE NYAKURI.

PARITIKILE Z'IBANZE

Tega amatwi, aho kurera amaboko, mfasha gushira ku murongo iyi mvange y'ama PARITIKILE Y'IBANZE.

Aya yo afite uburebure bwa onde ya Compton λ_c buto cyane.

Izo paritikile za mase ziremereye cyane zitwa HIPERONI (*)


Hanyuma hakaza za HADORONI. POROTONI na NETORONI (kimwe na ndwanyaporotoni na ndwanyanetoroni) zibarizwa nazo muri iryo tsinda. Zifite ububasha bwo kwiyegeranya zikarema AMANUWAYO. Kugirango ukore izo paritikile, hakenerwa ubushyuhe bw'umurasire by' igipimo gisumbye 10^{13} K, ni ukuvuga dogere miliyaridi ibihumbi cumi.

Ni igipimo cy'ubushyuhe mpagurukiro.

Uburebure bwa onde ya Komputoni bwa za porotoni na za netoroni bungana na cm $1,35 \cdot 10^{-22}$. igice kimwe kuri igihumbi cy'igice kimwe kuri miliyaridi cya cm.

BIRABUJIJWE GUSUNUTSA
IZURU MURI NETORONI


(*) Ibaho rya byo nta kiryemeza, hashingiye k'ubumenyi tugezeho muri iki gihe.



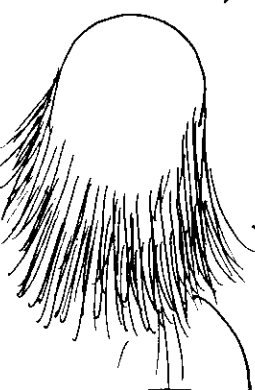
HADORONI, riturutse
kuri HADROS, rivuze ngo
"gitekeye", mu kigiriki.



Tireziyasi,
uzi ikigereki ?



Mu byumvikana, hari umubare
wa NDWANYAHADORONI ungana
n'uwa za HADORONI.



Mukurangiza, dore za LEPUTONI (*)


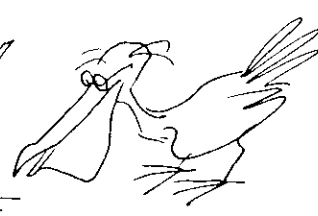
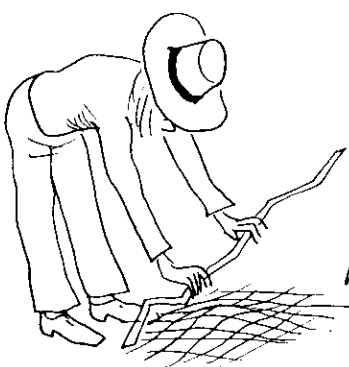
LEPUTONI



NDWANYALEPUTONI

Kugirango uzikore, hagomba byibuze igipimo
cy'ubushyuhe bw'umurasire kingana na dogere miliyaridi 6
(igipimo cy'ubushyuhe mpagurukiro) kirahagije.

Izwi cyane mu ma LEPUTONI ni elekitoroni, hamwe n'impanga
ya yo ndwanya-elegitoroni, bita kandi POZITORONI. Muzibonera ko
igipimo cy'ubushyuhe mpagurukiro, cyo gukora elegitoroni, ari gito
inshuro 1850 ugereraniye n'igipimo cy'ubushyuhe mpagurukiro
cya za porotoni cyangwa netoroni.



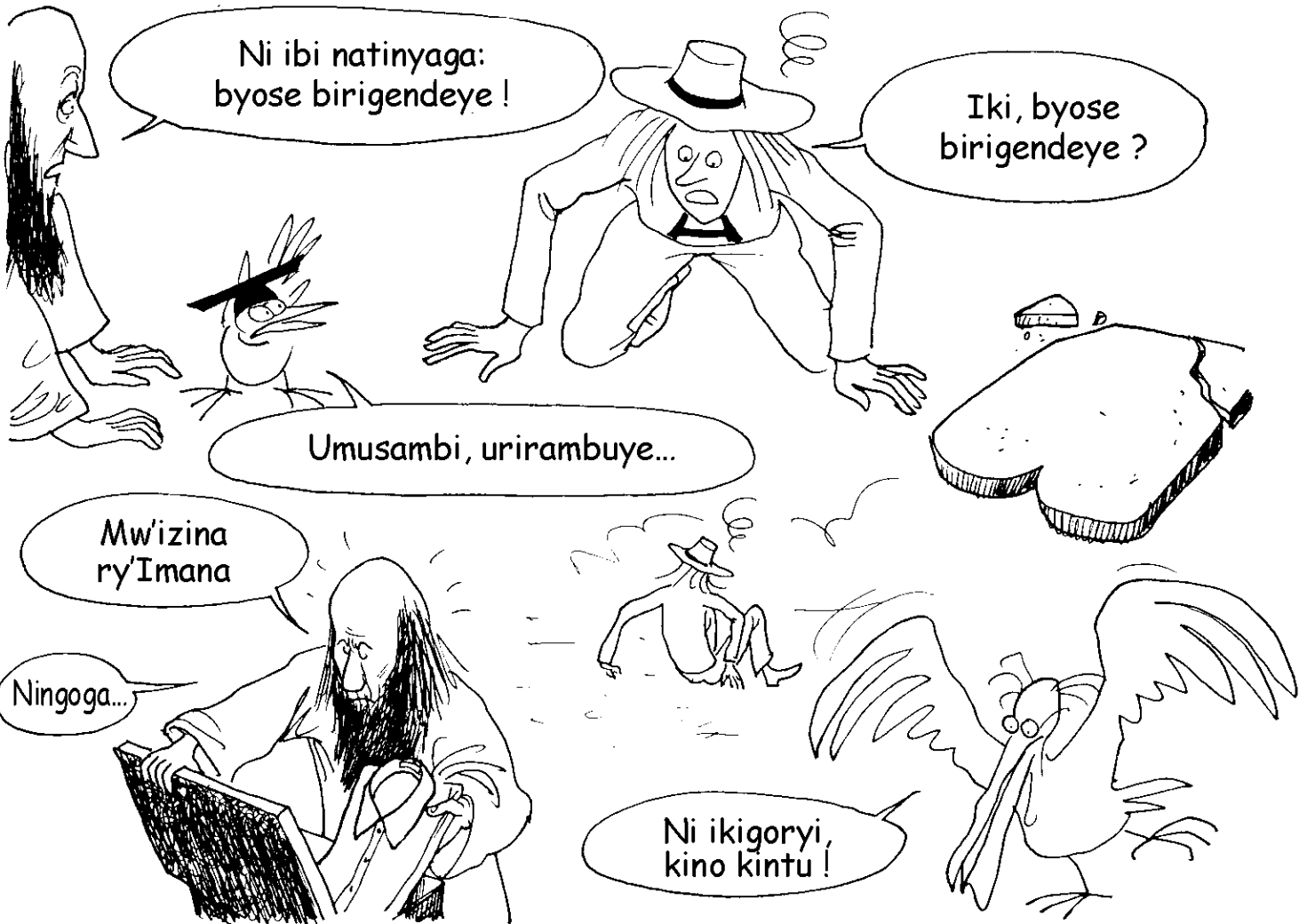
Ni ibyumvikana kuko hakenewe ingufu
ziri muni inshuro 1850 kugirango
hakorwe elegitoroni ugereraniye
n'izikenerwa mu kurema porotoni.


(*) bituruka mu kigiriki LEPTOS, kinanutse.

BYOSE BIRIGENDEYE




Imiterere yari, cyane, nsabagihe (igihe nta kindi cyasabaga uretse guseruka). Koronotoroni itangira gukora ubwo rero EVENOMA yambere iba irabaye, UMWANYA wambere.






Muri hehe ?
Ni ibiki bibaye ?




Ni IKWEDUKA, ishwiragira...
Iniveri irikweduye. Mbabarira...

Nigiriye
ahandi.

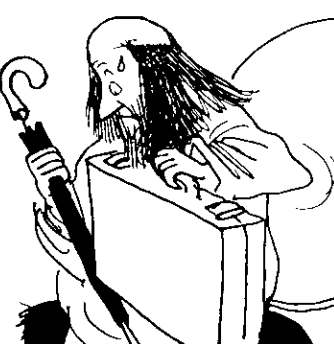
Impinduka, jye,
sinyihanganira!



Ehee !!!



Muraza kubibona, mu gihe
gito biraza koroha gato.



Ni ukuri, arabidutanye
ngo bidupfane.

Murabeho,

imikomereze myiza.

Byapfuye kandi!



Ese yaciye he ?

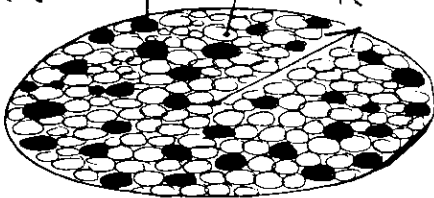


Umuntu yagirango ni ibipfundikizo
bya ruhurura. Ese byaba ari amarimbi
ya za Iniveri?

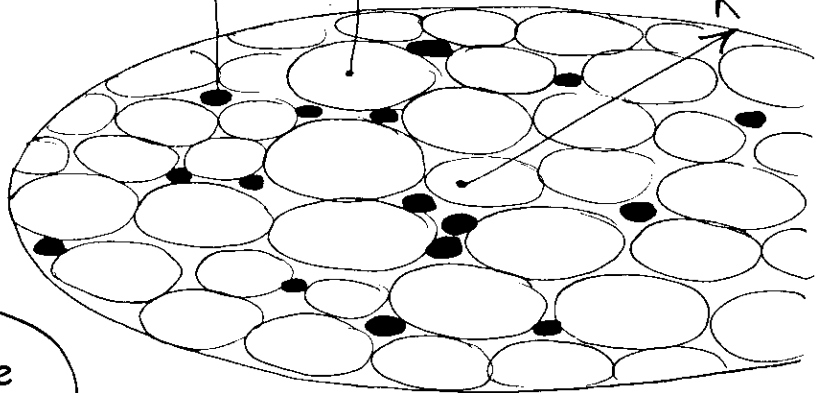
UBUDAHINDUKA BWA MASE

Reba ibiriho biba: ni za fotoni zibyimba.
Paritikile nyamatsiyeri, zo, nti zibyimba.

Matsiyeri fotoni

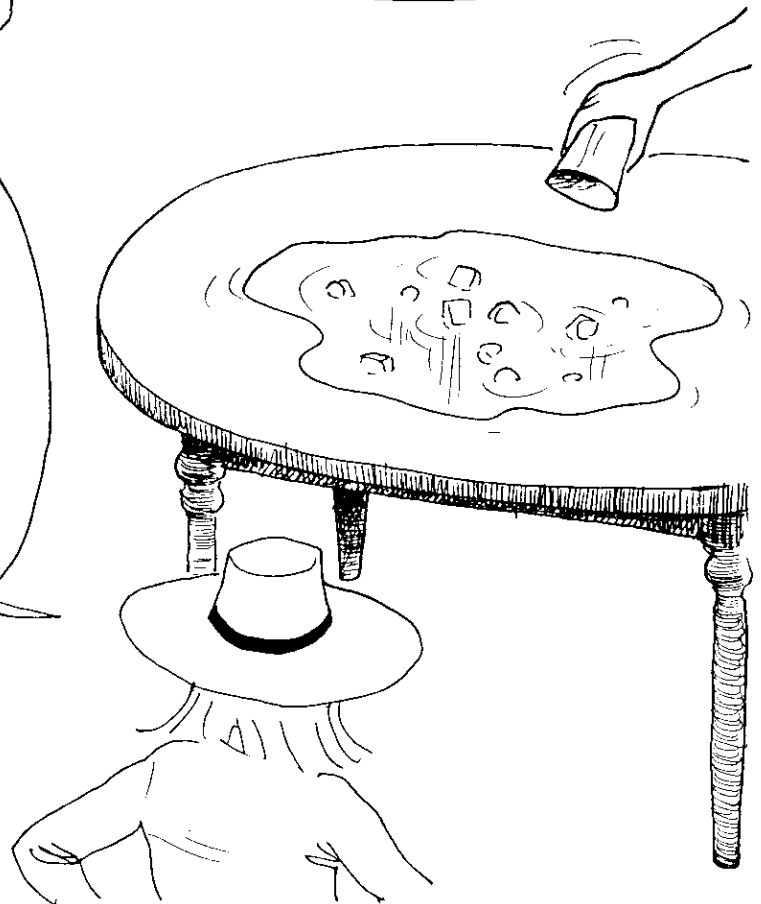


Matsiyeri fotoni



Matsiyeri, ni
esipase yakonje cyane
igahinduka barafu.

Ibi bituma umuntu atekereza
ibiba iyo usutse, ku meza,
ikirahure cyuzuye amazi na barafu.
Mase y'amazi irasakara, irikwedura.
Za barafu zo, zikurikira iryo
sakara, ariko zikagumana
dimansiyo ya zo.



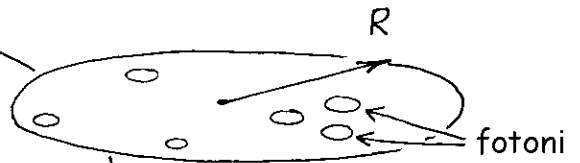
Nk'uko dimansiyo ya zaparitikile nyamatsiyeri ifatanye na mase ya zo, ubwo rero birigaragaza ko MASE IDAHINDUKA.

Dukurikije incurikaburyo, itsinda ry'amafotoni (abyimba) ritakaza INGUFU.

Niba R ari reyo ya Iniveri, kandi uburebure bwa onde λ y'amafotoni bukurikira uko gukweduka (λ ihinduka nka R), mpita mbonako igipimo cy'ubushyuhe bw'umurasire, gihinduka nk'uko $1/\lambda$ ibigenza, igabanuka rero nka $1/R$.

Byose bigenda nk'aho iniveri ariyo yicurira esipase nyakuri ya yo, KOSIMOTOPE (*) ininda ... umwanya urimwo ubusa...

Matsiyeri n'urumuri ni amaforoma abiri anyuranye y'ikintu kimwe: INGUFU-MATSIYERI. Fotoni zigumana umuvuduko wa zo wa km/s 300.000 ariko zigatakaza ingufu.



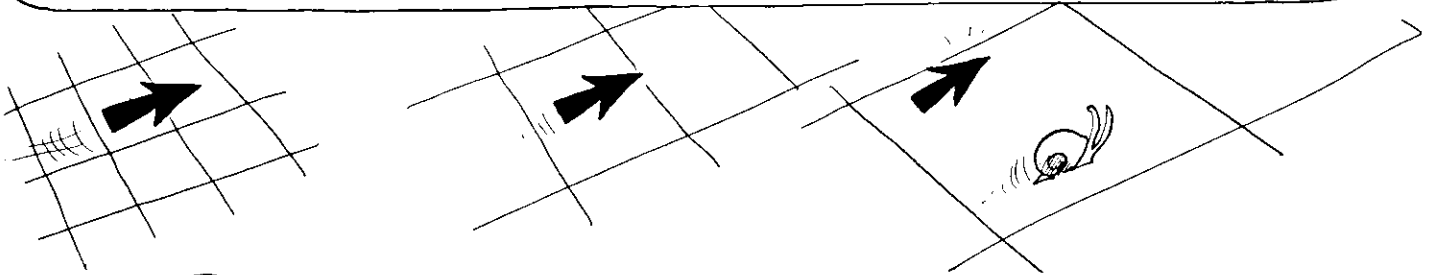
(*) biturutse kuri kosimosi: COSMOS na topos: AHANTU (ahantu Iniveri yicaye.)

Dore igishushanyo cyerekana neza ikururuka rya fotoni n'itakaza ry'ingufu rihakomoka.



Ariko se matsiyeri yifata ite muri iryo kweduka ?

Iniveri ininda esipase nk'uko igishishwa cy'igi gikorwa. Uko igihe gihita ni nako paritikile zibona inzira yo kunyuramwo. Iyo ingano ya Iniveri yikubye kabiri, umuvuduko wo kwitingisa w'ama paritikile nyamatsiyeri ugabanukaho icya kabiri. Ingufu nyarugendo za byo zigabanywa rero na 4: umuvuduko wo kwitingisa uhinduka nk'incurikamubare ya reyo R ya Iniveri, birtyo rero igipimo cy'ubushyuhe T_m bwa matsiyeri buhinduka nka $1/R^2$.

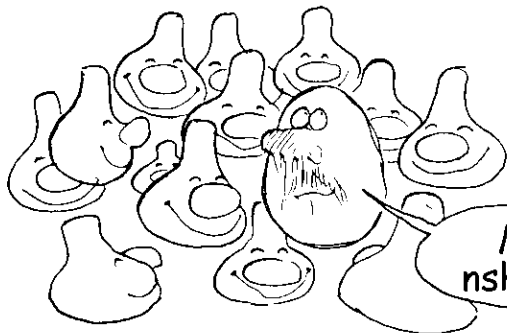


Ariko... twabonye mu kanya ko ubushyuhe bw'umurasire T_R gihinduka nka $1/R$. Matsiyeri ifite rero umuco wo gukonja vuba ?



Uuhu ndananiwe..

Urtyo. Ariko isekurana rya fotoni-matsiyeri rirayishyushya. Kenshi rwose, ayo masekurana ahamishaho igihe cy'uburinganire nyangufubushyuhwe ($T_R = T_m$), mu gihe cy'umwanya utari muto cyane.

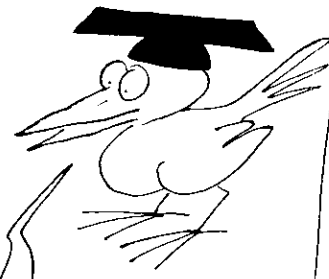


Murakoze, nshuti nzanjye

Igice kimwe kw'ijana cy'isogonde




Ama porotoni, ama netoroni, ndwanyaporotoni na ndwanyanetoroni zigenda k'umuvuduko wa kimwe cya cumi cy'umuvuduko w'urumuri c gusa.



Igipimo cy'ubushyuhwe ($T_R = T_m$) cyaramanutse kugera kuri dogere miliyaridi ijana, ni ukuvuga neza mu nsi y'igipimo cy'ubushyuhwe mpagurukiro, kingana na dogere miliyaridi ibihumbi cumi. Zagiye zituritsanya ebyiri ebyiri k'umuvuduko uhanitse none hasigaye imwe kuri miliyaridi imwe.





Sofiya, porotoni, netoroni,
ndwanyaporotoni na ndwanyanetoroni
nyinshi zarayonze. Ariko se kuki elegitoroni
na positoroni (ndwanya-elegitoroni)
zingana ziritya zo zasigaye ?

Igipimo cy'ubushyuhe
mpagurukiro bwa za
elegitoro kingana na miliyaridi
esheshatu za dogere gusa.

miliyari esheshatu
za dogere gusa... urumva ?

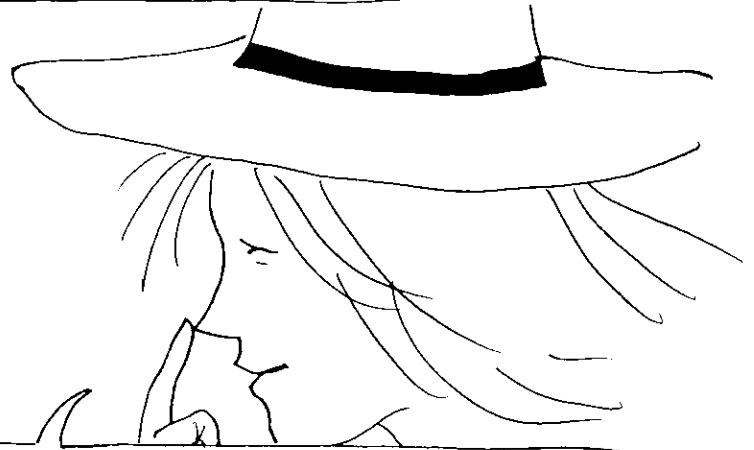
Twavuga
ko bitanga
amafu.

Hari ikintu kidasobanutse: igipimo cy'ubushyuhe ni dogere miliyaridi
ijana. Za porotoni, netoroni, ndwanyaporotoni na ndwanyanetoroni
zigenda k'umuvuduko wa kimwe cya cumi cy'uw'urumuri.
Ariko elegitoroni zo ziracyari relativisite.

Yego, kubera iki ?

Aho hantu haracyari buri gihe mu nteruro y'UBUNGANISHA NYABUSHYUHENGUFU: Irematsinda nyabubiri rya za esipese zose, hamwe n'umurasire, ni inyakarindi buri gihe. Ingufu z'umuvuduko z'amaparitikile nyamatsiyeri zingana, ufatiye hagati na hagati, na :

$$\frac{1}{2} M_{\text{porotoni}} (V_{\text{porotoni}})^2 = \frac{1}{2} M_{\text{elegitoroni}} (V_{\text{elegitoroni}})^2$$



Buretse... nk'uko mase ya elegitoroni iri nto inshuro 1850 ugereraniye n'iya porotoni, rero ni ukuvugako, nta shidikanya ko, kugirango hazibwe icyuho, ku igipimo cy'ubushyuhe kanaka, umuvuduko wo kwitingisa wa elegitoroni ari munini cyane.

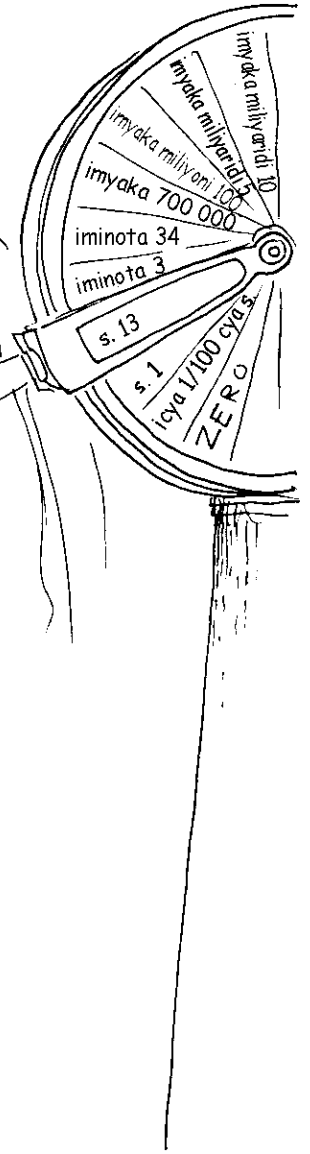
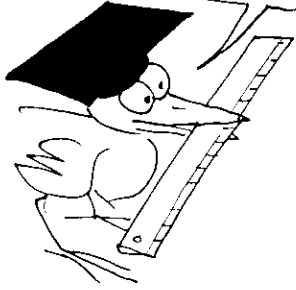
Ubireba, nk'uko ingufu-hagurukiro kugirango hakorwe paritikile ya masse m ari nkuko bisanzwe mc^2 gusa, kuva umuvuduko wo kwitingisa V ubaye nk'ugaragara muto cyane kuri c , ikorwa ry'ayo ma paritikile rirahagarara kandi n'igabanuka ry'imiturire rikikora.

Mu yandi magambo: kuva itsinda rya za paritikile nyamatsiyeri riretse kuba rolativisite, iryo tsinda rirahona.



Amasegonde
cumi na tatu.

Igipimo cy'ubushyuhe
cyaragabanutse kugera kuri
dogere miliyaridi eshatu.



Ahe, reba za elegitoroni
na za ndwanyelegitoroni.
Mbega irigita-honero !



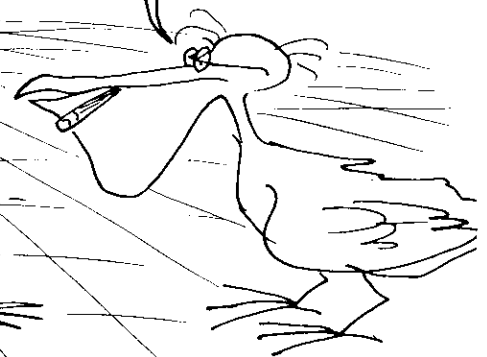
Ni ibisanzwe, turi mu nsi
y'igipimo cy'ubushyuhe hagurukiro.

Ihonero nyaryo nyakosimikye ryagereranywa
n'iryitiriwe umutagatifu Baritelemi !



Hariya naho
kandi, hazasigara
gusa imwe kuri
MILIYARIDI !

Mbega amakuba...



Habuze gato gusa, nta cyari gusigara ...
uretse amafotoni. Amahirwe, siko se...

Yenda hashobora
kuba hari izindi Iniveri
zipfubisha, hirya.

Amayobera amwe mu ayakomeye yo
muri kosimologi, ni ayo kudashobora gusobanura
ukuntu matsiyeri na ndwanyamatsiyeri byahondanye
ariko ntibiyongeye byose icyarimwe.

Kuri iki kiciro cy'amateka, ni bimwe
buri gihe: hari igihe twirengagiza ikibazo
cya NDWANYAMATSIYERI. Pfffft !...
yaburiwe irengero, ndwanyamatsiyeri...

Tireziyasi, ndakwibutsa
amasezerano yacu. **IBIKORWA** byonyine !
Ntabyo gutekereza birengeye!..(*)

Iby'abapolisi
b'ubumenyi
byandambiye

Psst..!

(*) Alubomu imwe izaba by'umwihariko ijyanye n'intera z'ibitekerezo birengeye.
" IBIRORI BY'UBUMENYI: Ikusanyo ry'ibitekerezo byo mu bihe birimbere"

IBIHE BY'IMIRASIRE ITWIKANA

Ama paritikile, hari UBUSHYO bwa yo.

Nta kintu gitangaje muri iyi Iniveri usibye urumuri



INGUFU-MATSIYERI, byari mu migabane ingana mu foruma ya matsiyeri, ndwanyamatsiyeri k'uruhande rumwe, ftoni na netirinosi k'urundi; byabaye ubu rukumbi mu foruma ya ftoni na netirinosi, ni ukuvuga iforuma y'imirasire. Mu busanzwe, buri gihe iyo uburebure bwa Iniveri bwikubye kabiri, dansite ya matsiyeri iragabanuka. Ni kuyonga bisanzwe.

Ku musambi, iyo R yikubye kabiri, dansite yo igabanuka ku nshuro $2 \times 2 = 4$. Muri Iniveri yacu nyadimansiyo eshatu, mu by'ukuri, iyo dansite igabanuka ku nshuro $2 \times 2 \times 2 = 8$.

Indemere ya matsiyeri ihinduka nk'incurikaburyo ya kyibe y' "uburebure" bwa "reyo" ya Iniveri.

Ariko, kuri twebwe, amafotoni, ni agateramakuba. Iryo kweduka "rituvomamwo" buhoro buhoro ingufu zacu zose. Inganamubare y'ingufu-matsiyeri tujyendana igabanuka nk'incurikaburyo ya reyo R ya Iniveri.

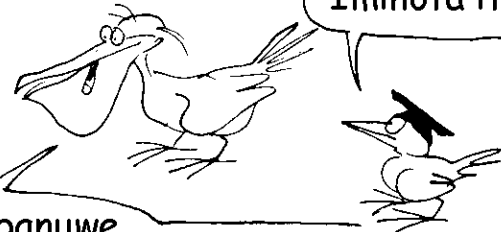
Ibyo bituma dansite y'ingufu-matsiyeri iri mu foruma ya ftoni ihinduka nk'incurikaburyo y'inkubabubasha ya kane ya R.

Kuva matsiyeri ikiremye itsinda nyabubiri na za fotoni, zikomeza kuyishyushya bihoraho. Ibi birakomeza kugeza igihe igipimo cy'ubushyuhe (rusanjye: $T_R = T_m$) kimanuka kugera kuri dogere K 3000, ni ukuvuga mu gihe cy'imyaka 700 000.



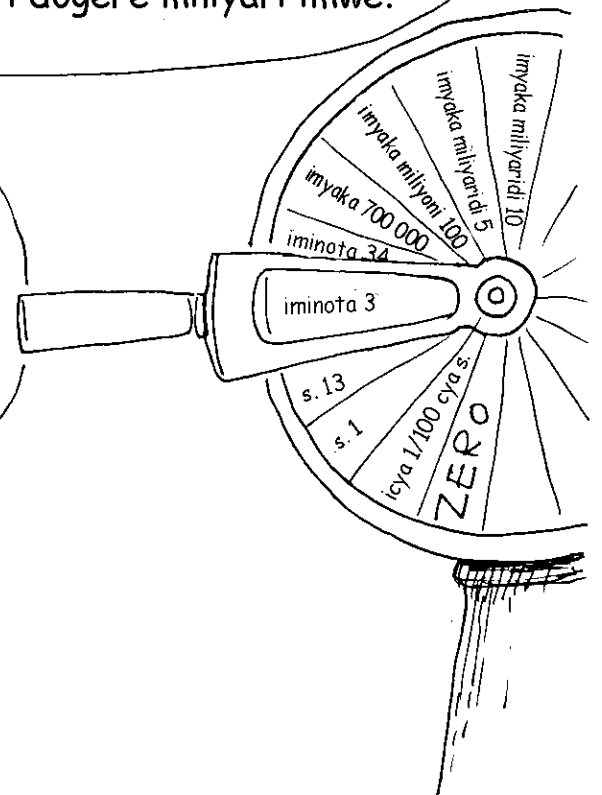
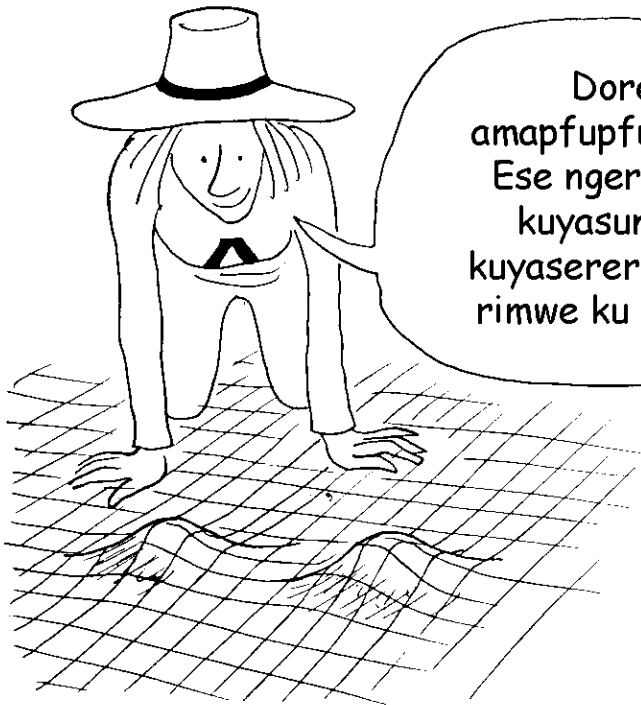
IREMWA RY'AMANIKELEWO

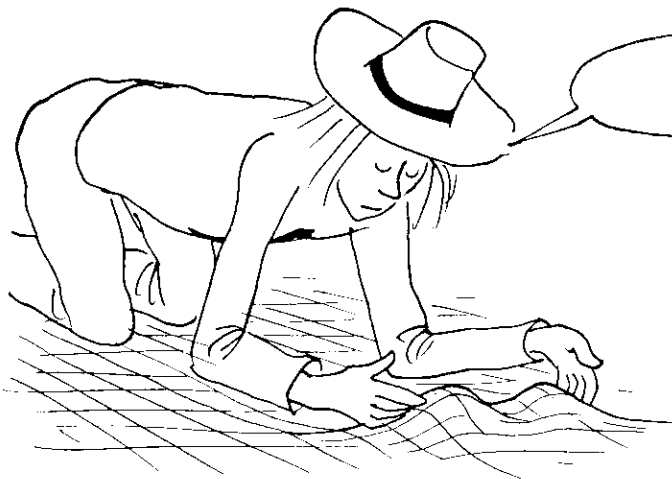
Iminota itatu



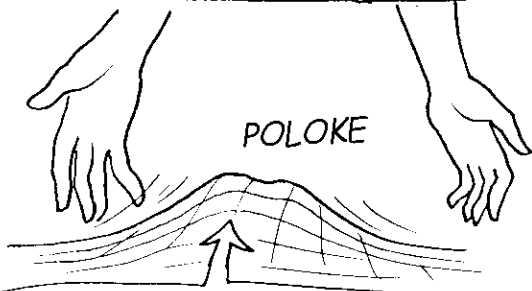
Yego...ugereranije n'igihe-mpagararo gisobanuwe kuri paje 31, ku gihe cy'igice kimwe cy'ijana cy'isogonda, uburebure R bwa Iniveri bwakubwe inshuro ijana kandi n'igipimo cy'ubushyuhe ($T_R = T_m$) cyaramanutse kugera kuri dogere miliyari imwe. Ntagisigaye hanyuma se ?...

Dore amapfupfu abiri. Ese ngerageje kuyasunika, kuyasererekesha rimwe ku rindi ?





Zitangira zisunikana

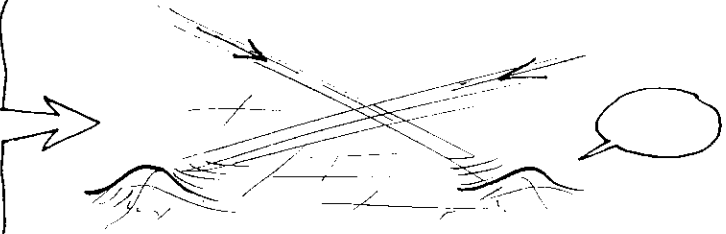


Hanyuma zirakururana kugeza zifatanye zigakora ikintu kimwe.

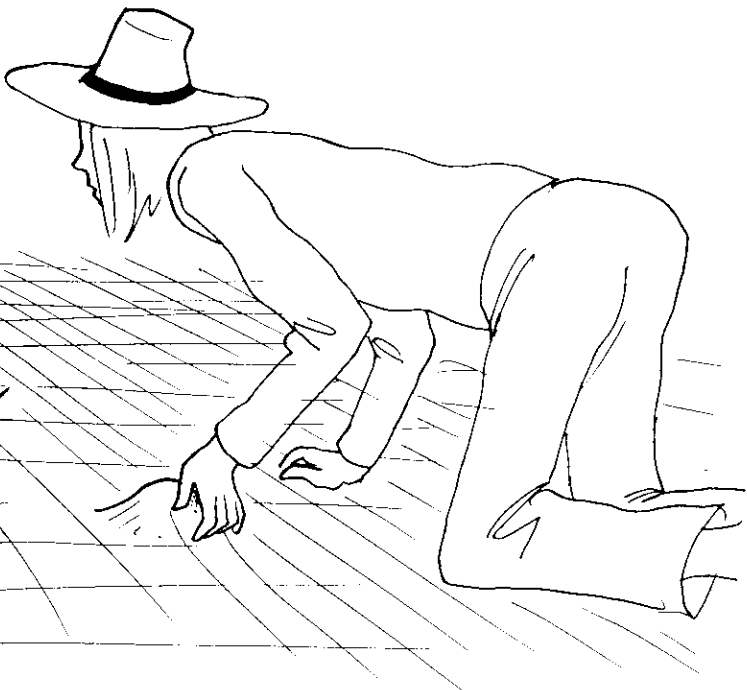
Iyo amapfupfu abiri asekuranye, hari ibintu bitatu bishoboka, rimwe ridundika ku rindi.




Iyo amapfupfu afite umuvuduko mwinshi cyane, anyuranamwo vuba ku buryo atabona akanya ko gusekurana.



Ashobora rero kwifatanya iyo gusa umuvuduko wo kwitingisa n'igipimo cy'ubushyuhe biri mu busitani buzwi kandi busobanuwe neza.



Kandi isekurana rya cyane n'irindi pfupfu rya gatatu ricagagura iyo mitererempagaze yakozwe.

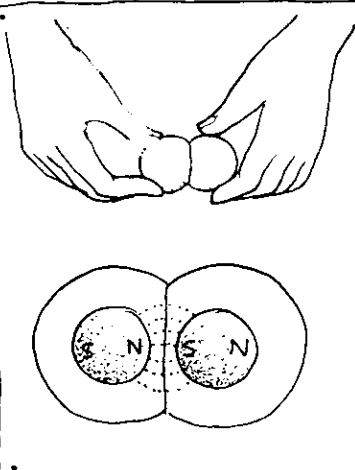


Izo nsubizabikorwa z'IMATANISHA zitanga AMANUWAYO ya mbere ya z'ATOME. Iyo MORUFOJENEZE izaserura AMAFORUMA ya mbere, IMITEREREMPAGAZE ya mbere ya Iniveri.

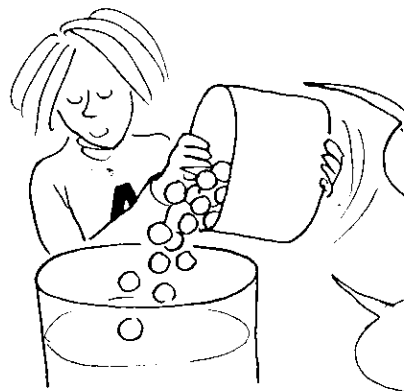
A

Iyo nkuru, irasekeje cyane. Hagomba kubaho imbaraga nkurura n'imbaraga nsunika. K'uburebure bugari, imbaraga nsunika ziraneshya, naho ku burebure bugufi ni imbaraga nkurura zinesha.

Ngiye gufata za sumaku nzishyire muri za siferi zikozwe muri muse.



Muse irika mu buryo bworoshye; ni ntsindagira ama siferi abiri imwe ku yindi, zisigara rero zifatana imwe ku yindi.



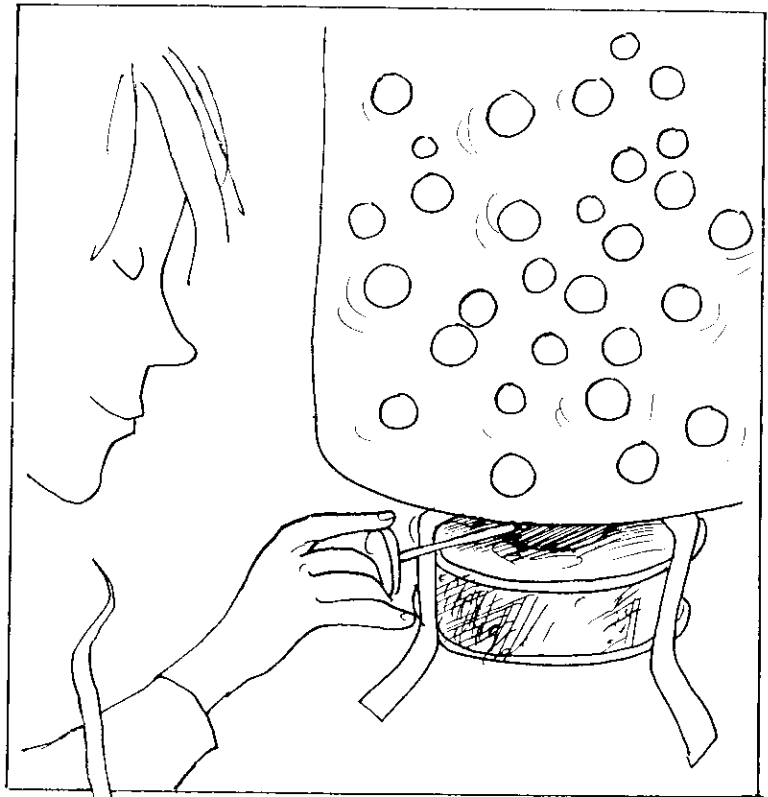
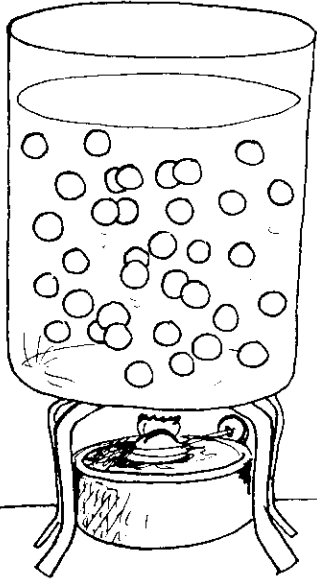
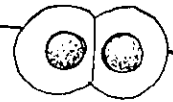
Ngiye gushyira iyo mipira mu base nini yuzuye amazi...

.... Kugirango bishobore kugenda.

Imbaraga ebyiri zirigaragaza. Imwe ya nkurura: y'izo sumaku; indi mbaraga nsunika: ya muse iyo itsikamiwe. Iyo ya mipira ikoranyeho, za mbaraga zirigaragaza. Intera y'imbaraga nyasumaku aha ngaha iteye ku buryo muse igomba kuba itsindagiwe kugirango zigaragaze. Hari ahantu, hateye k'uburyo izo mbaraga zigeraho zikaringanira.

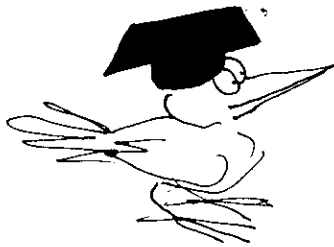


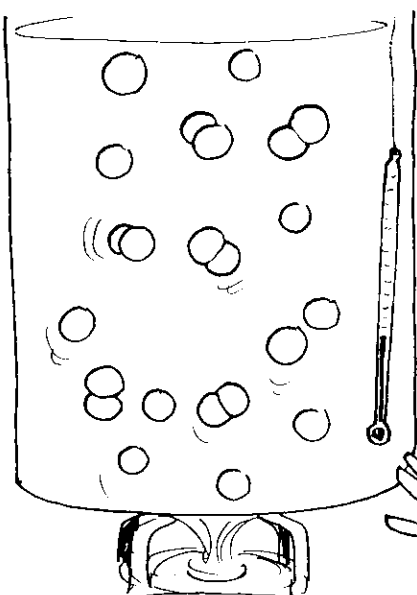
Muse iha ubwo bubumbe dansite ingana rwose n'iy'amazi. Noneho rero ubu naremye ivumbukangendo zo kwitingisa igihe mbishyuhije.




Igihe ubushyuhe ari buke, ayo mabule azadundika buhoro imwe ku yindi, ariko nta kindi kizaba. Iyo zisekuranye zirebana, nta mbaraga zihagiye kugirango zitsindagire iyo muse, bishobore no gutuma imbaraga nyasumakumashanyarazi zigaragaza ku burebure bugufi, zikora.

Ni byiza, ngiye kongera ubushyuhe





Aho, birakunda! ni igipimo cy'ubushyuhe cyiza (kiruta igipimo cy'ubushyuhe MPAGURUKIRO). Intera yo kwitingisa irahagiye.

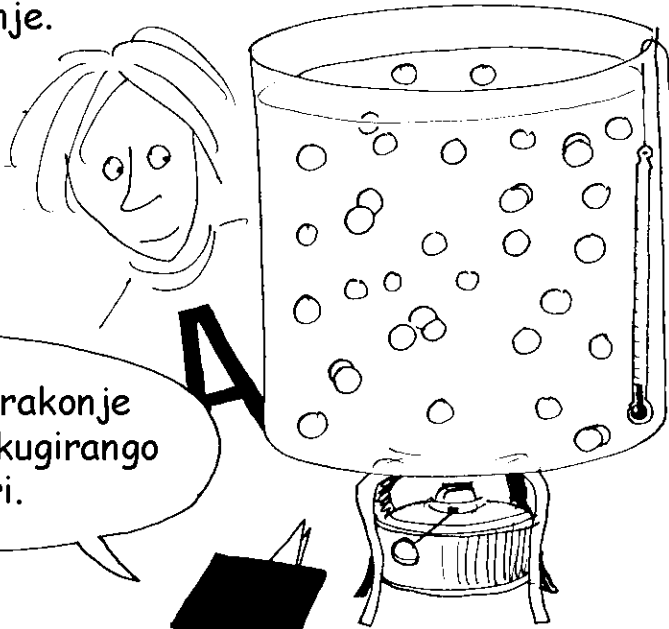


Mu bigaragara, amabule aramatana abiri abiri.

Iyo nshyuhije cyane, iyo MITEREREMPAGAZE icibwa n'itingiswabushyuhe.

Hanyuma se mbikonjesheje ?

Anselimi areka umwuka usubira ibukonje. INYURANAMWO riragabanuka. Bigeze ahantu hamwe amabule amwe ariyegeranya mu matsinda nyabubiri. Ariko, igipimo cy'ubushyuhe gikomeza kugabanuka, iryo REMWA RY'AMANIKELEWO rirahagarara.

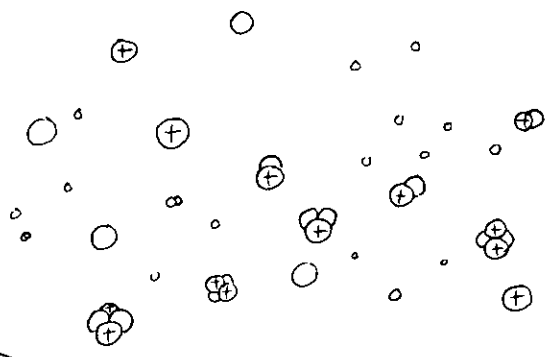


Nta kintu cya korwa, ubu ngubu. Harakonje cyane. Amabule ntiyitingisa bihagiye kugirango ashobore kumatana abiri abiri.

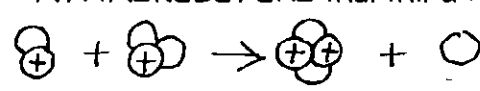
Turi muni ya MPAGURUKIRO

Ikintu nk'icyo cyaje kuba igihe igipimo cy'ubushyuhe bwa Iniveri cyamanukaga kikagera muni ya **dogere miliyaridi imwe**. Ni ukuvuga nyuma y'**IMINOTA mikye**. Ubwo rero imitererempagaze nyabubiri, nyabutatu, cyangwa iy' "utubule" tume irirema.

⊕ POROTONI ○ NETORONI



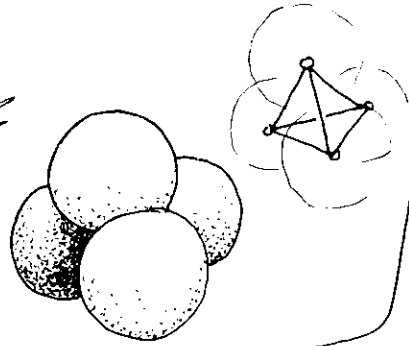
Ariko DETERIYOMU na TIRITIYOMU bikoze ako kanya, birivanga hakurikijwe INSUBIZAGIKORWA NYANIKELEYERI ikurikira:



Deteriyomu + tiritiyomu bitanga heliyomu + netoroni
 icyo gihe, Iniveri yari I BOMBE YA IDOROJENE

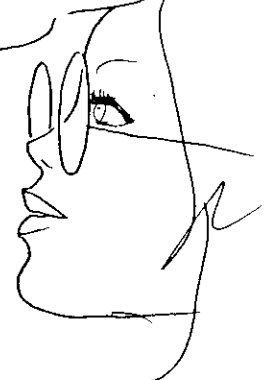


Rero, byose bigiye kwihindura muri eliyomu ?



Nuwayo ya heliyomu ni simetirike cyane, iregeranye kandi irumutse. Iyaba igipimo cy'ubushyuhe cyagumaga hamwe, matsiyeri yose yari kuba yarahindutse heliyomu. Ariko nyuma y'iminota 34, igipimo cy'ubushyuhe cyaramanutse kugera ku ma dogere miliyoni 300 kandi iryo iremwa ry'amanikelewo rigiye guhagarara.

Za nikelewoni ntizikigira umuvuduko uhagije kugirango zitsinde isunikana nyamashanyarazi-gishyitsi (+ asunika +). Byose bizahita birangira.

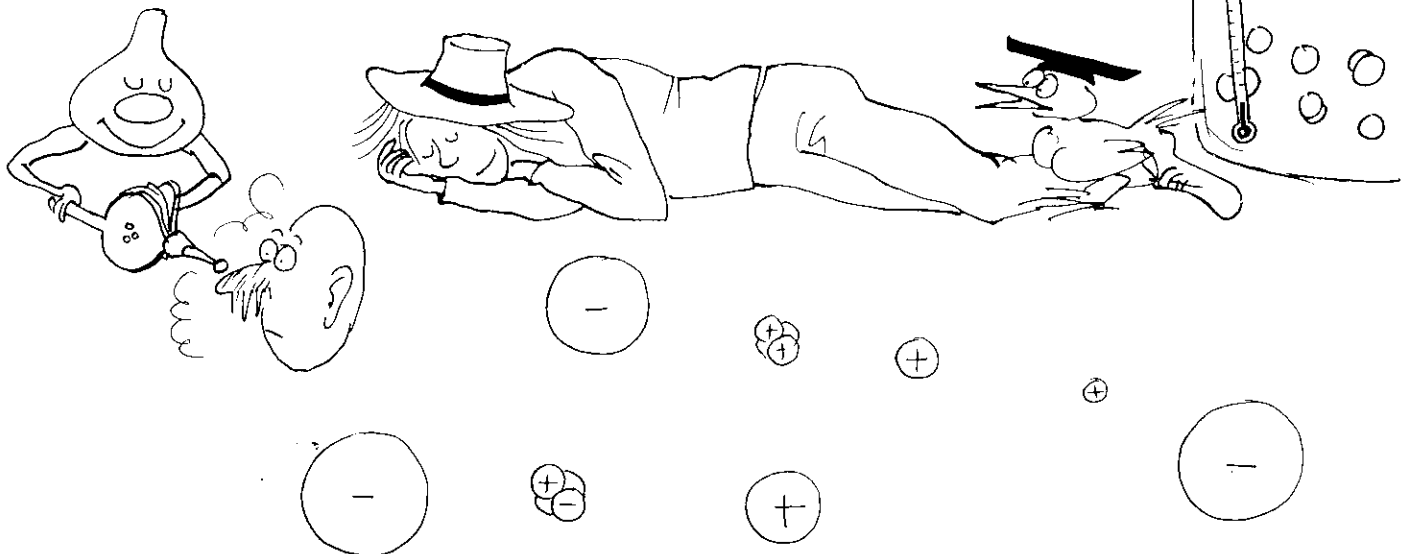


Amanetoroni yigenga yanyuma yaraseniyaguritse.
Mu busanze imbaraga mfatanyi zayo ni nkeye; birtyo zikihinduranya,
mu masegonde 109, mw'itsinda nyabubiri POROTONI-ELEGITORONI.



Nyuma yiyo nteruro, hagaragaye umufa wambere ugizwe na FOTONI, na NETIRINOSI, na POROTONI, na ELEGITORONI hamwe na NUWAYO za HELIYOMU. Matsiyeri yigabaniye, mu buremere, nk'uku gukurikira: 25 % bya HELIYOMU na 75 % bya IDOROJENE (porotoni zijyenga).

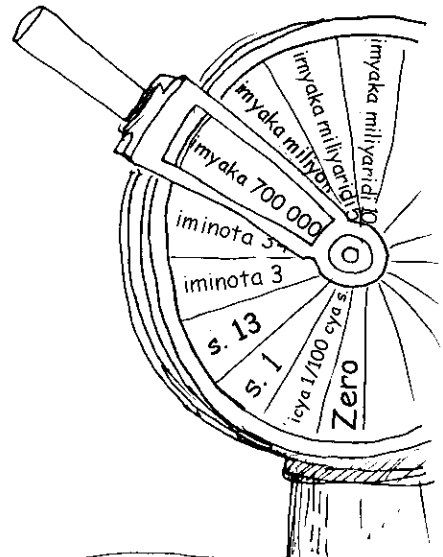
Mu gihe cy'imyaka 700000 nta kintu na gito cy'UBUNZUGUNYA kigeze kiba. Iniveri yakomeje kwikwedura, na fotoni nazo zigenza zicyo. Umwuka wa fotoni wakomeje guha ubushyuhe matsiyeri, kugirango ibipimo bibiri by'ubushyuhe T_R na T_M bigume bingana (uburinganire nyangufubushyuhe).



N'igipimo cy'ubushyuhe kiramanuka kugera kuri dogere Keluvine 3000.

INIVERI IBONERANA

Iyindi nshorerabikorwa nyamforomankomoko yinjiye mu mukino. Imbaraga nyamashanyarazi ziganisha mu gufatanya za elegitoroni kuri nuwayo kugirango hakodwe za atome. Itingisa nyabushuhe ryaragabanutse cyane bihagiye kuburyo iyo mitererempagaze itazasenywa, ako kanya imaze kubakwa, mu masekurana n'iyindi atome cyangwa hamwe n'andi matsiko-ngizi y'iyi mvange.



Buhoro buhoro ama elegitoroni yigenga yose yakaciwe n'ama nuwayo.

Ziriya atome ziteye inkeke... hamwe na za elegitoroni zazo. Jye nsinjya mbiyamwo!

Hanyuma iniveri irahinduka iba i BONERANA.

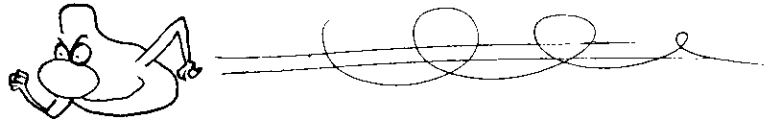
Ese ushatse kuvuga iki n'iryo jambo wakoresheje ryo kubonerana? ese ubundi yari yijimwe?!?

Mbere, amafotoni yagonganaga buri gihe na matsiyeri. Nta fotoni ni mwe yacaga iyindi nzira muri icyo kirere.

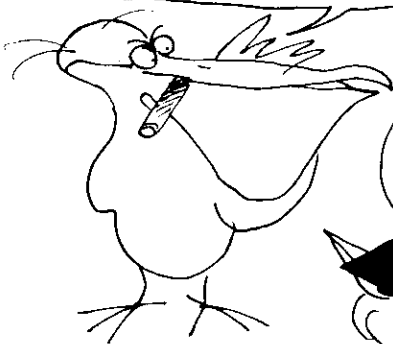
Pufufu!

ISENYAGURIKA RY'I REMATSINDA NYABUBIRI NA RYO

Ubu bya rangiye, amafotoni ashobora kwambukiranya Iniveri yose atanamenyeko matsiyeri ihari: habayeho ISENYAGURIKA RY' IREMATSINDA NYABUBIRI. Kubera impamvu ebyiri. Ubwa mbere umwanya urahari. Ubwa kabiri, amafotoni ahereranya ibikorwa gacye na matsiyeri mburamashanyarazi (atome).



Ariko, turebe, za telesikope zitwoherereza amashusho, ubirebye neza, aturutse "Y'ako kanya ko muri kahise ..."



Yego, ariko naho waba ufite telesikope y'ubushobozi butangaje, ntabwo bizashoboka nagato kwitegereza I fenomene yabaye igihe Iniveri yarifite imyaka iri muni yi 700000.



Kahise, kahise ka kera cyane ka Iniveri kazahora ntakibuza katagaragara neza, kijimye gasa n'akarimwo ibicu.

Yego, ntibishoboka gusoma mu bwonko bwa Iniveri.



Matsiyeri na za fotoni byaje guhagarika guhererekanya ibikorwa, guhanahana ingufu, UBURINGANIRE MBARAGANYABUSHYUHE BWARASENYUTSE, noneho igipimo cy'ubushyuhe cya matsiyeri T_m cyahise kimanuka ni ngoga (nk'incurikaburyo y'inkububwacyo ya 2 ya reyo ya Iniveri), kurusha igipimo cy'ubushyuhe T_R cya fotoni, igipimo cy'ubushyuhe cy'umurasire, cyigabanuka gusa nk'incurikaburyo y'iyi reyo R.


Mwiriwe!

Ubu rero, umwe wese ni ukwimenya.

Bite! habaye iki?
Wagirango ijoro riraguye?
Kandi hahise hakonja
byabuze urugero,
ako kanya...

Iniveri igiye mu gihe gisa n'umwijima. Ikomeje gukonja. Ijuru rihindura ibara riva kuri vyoleti rijya k'umutuku wijimye, hanyuma ijoro rigwa nk'ikiringiti gikonje. Buri gihe hari miliyaridi imwe y'amafotoni yo kw'isoko kuri buri atome ya heliyomu cyangwa ya hidorojene. Ariko ayo mafotoni, yakweduwe n'igara rya Iniveri, yataye agatege.

BIGI BANGE, byararangiyeye. Impinduka zabaye zarakabije. Habuze gato, nta cyari gusigara (iparitikile imwe kuri miliyaridi imwe!). harijimye cyane nko mu muhanda wo mu kuzimu.



Fucuturu, mbega
ubukonje nk'ubwo
mw'ishyamba !

Uburebure bwa onde ya
za fotoni ni nka mm 0,15 ,
ni ukuvugako bujyanye
n'igipimo cy'ubushyuhe
bw'umurasire $T_R = -173^\circ C$.

Ama atome, yo,
aritemberera k'umuvuduko
wa m 150/s, ibyo bitanga
igipimo cy'ubushyuhe
bwa matsiyeri cya
 $T_m = -267^\circ C$

Byiza, ndemeza ko nashoboye
kumva uko Iniveri ikora.

Ariko hasigaye
ikibazo k'ijyenzi:
ese bimara iki?

Yego, Anselimi afite ukuri.
Ubundi se ibyo bize bite ?

Ese byari
ngirakamaro ?

Reka turebe, bigitangira hari IBYARIBYO BYOSE mu kavuyo gahanitse.

AKAVUYO

Hanyuma Iniveri yatangiyeye gukora IMITEREREMPAGAZE yagendaga irushaho GUKOMERA, ama nuwayo, ama atome...

Na vumbuye ihame nyakosimosi ry'ibanze.

Aha... nonese ni iki ?

KUKI WAKORA IBYOROSHYE IGIHE WASHOBORA GUKORA IBIRUHIJE ?

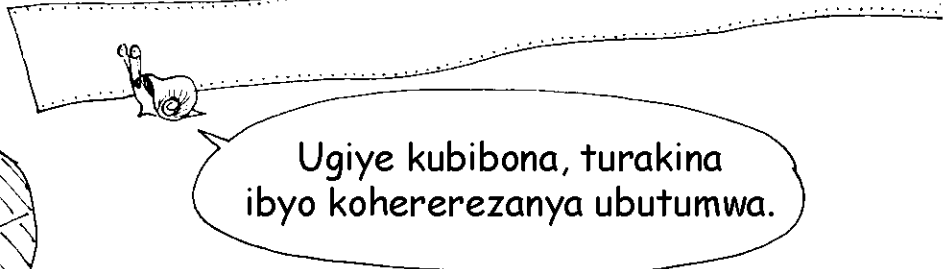
Wayii... ntabwo ari kabi, ako gakuru ka we. Ariko ni ibyifuzo, indoto z'umuhanga mu gutekereza. Ni iki, kitubwirako byose koko byajyenze nk'uko nguko ?



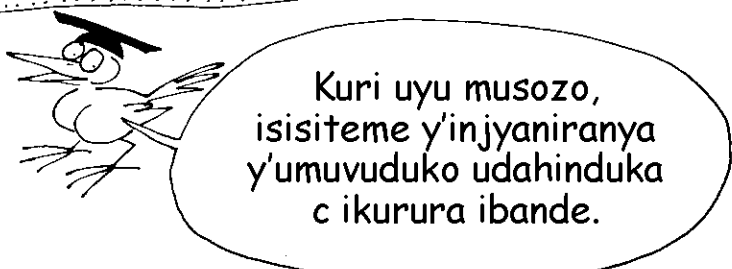
INYEREKANAGIKORWA YA DOPELERI



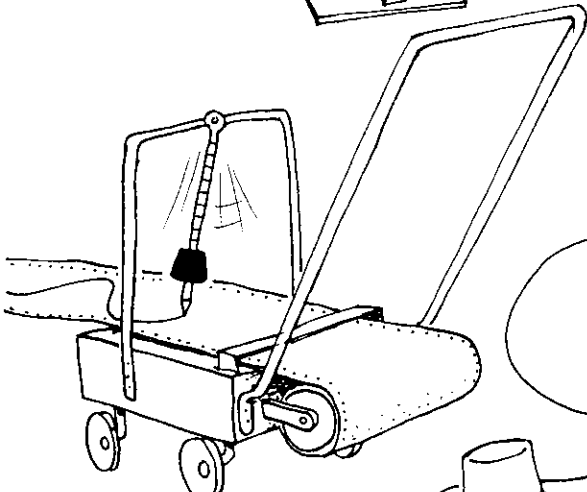
Murakora iki ?




Ugiye kubibona, turakina
ibyo kohererezanya ubutumwa.



Kuri uyu musozo,
isisiteme y'injyaniranya
y'umuvuduko udahinduka
c ikurura ibande.

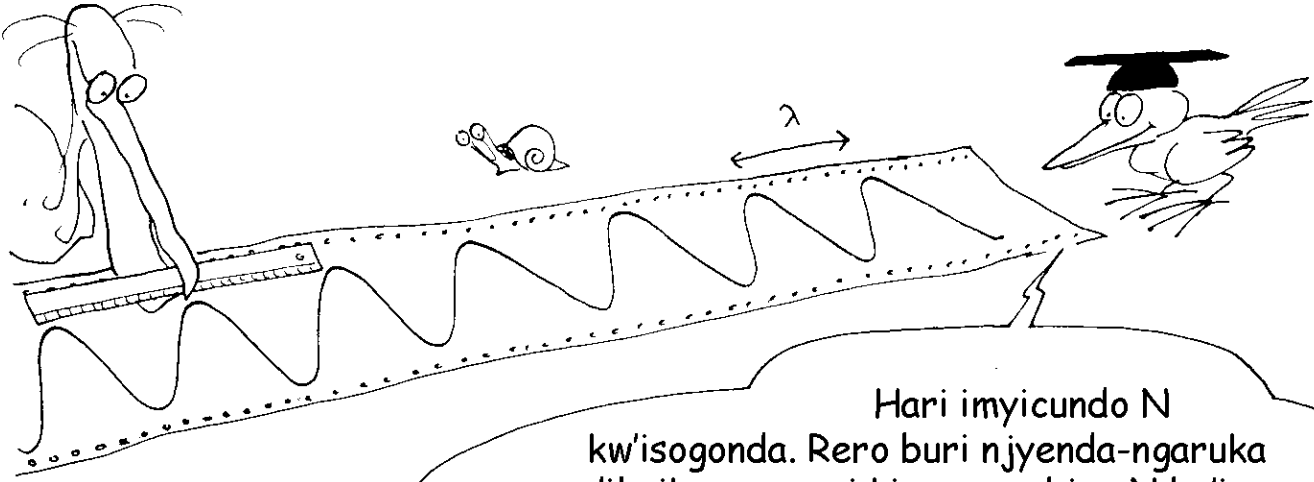


K'uwundi musozo, isisiteme
yicunda (pandile) ishushanya
sinuzoyide k'urupapuro

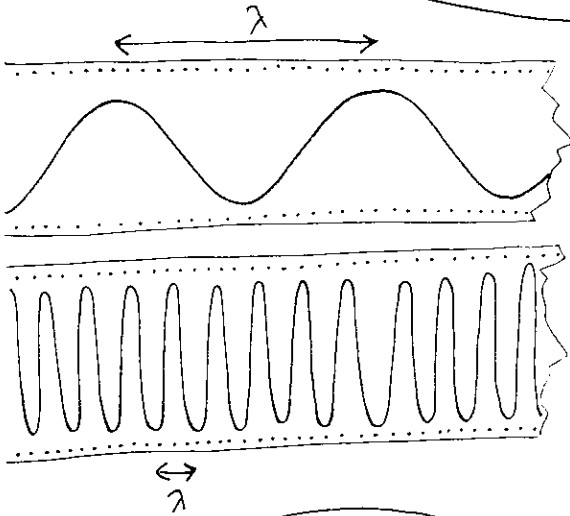


Nshobora gupimanya
ferekanse N, umubare w'imyicundo
kw'isogonda, mpimanyi je neza ikicaro
cy'uburemere ku kuboko
k'umwicundo.

Aha, ndabyemeye. Nanjye nshobora gupima uburebure bwa onde k'ubwakiriro.



Hari imyicundo N kw'isogonda. Rero buri nnyenda-ngaruka ya pandile ikorwa muri kimwe mu bice N by'isegonda: uwo ni PERIYODE ya onde. Muri icyo gihe, bande iricuma urugendo rungana na $\lambda = c / N$ (uburebure bwa onde).



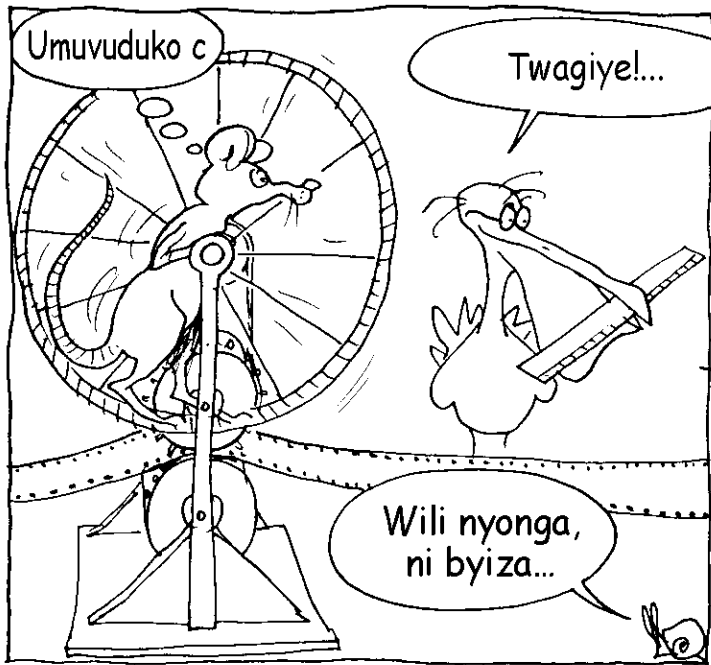
Ferekanse zo hasi, periyode ndende, uburebure bwa onde bunini. Ferekanse ndende, periyode ngufi, uburebure bwa onde buto.

Bituma abantu bohererezanya ubutumwa.

Itumanaho ni ingirakamaro.

Byiza. Ngiye kugerageza iyoherezabutumwa k'Urugendo rurerure.

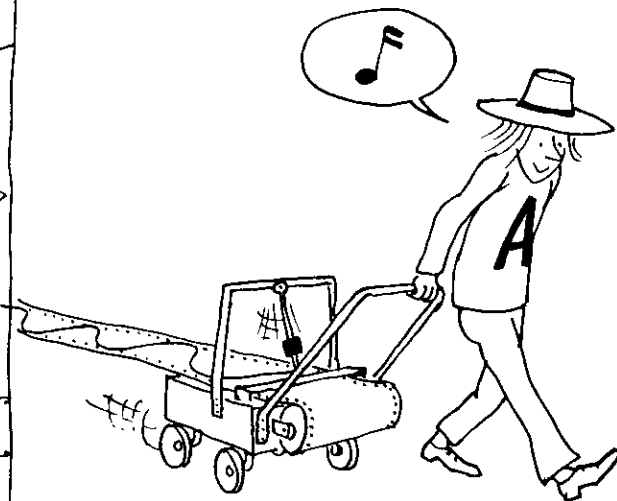
Mwiteguye?



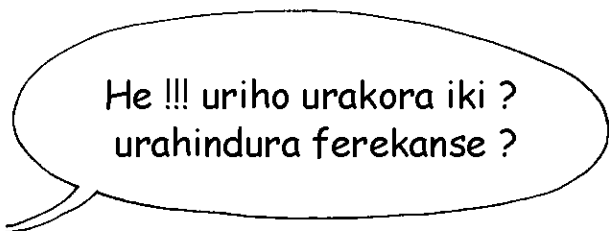
Umuvuduko c

Twagiyel...

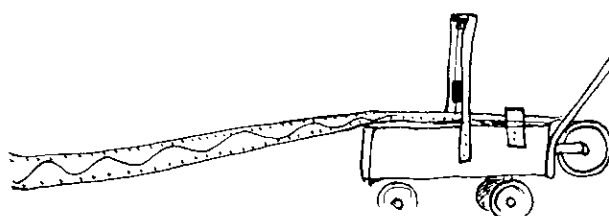
Wili nyonga,
ni byiza...



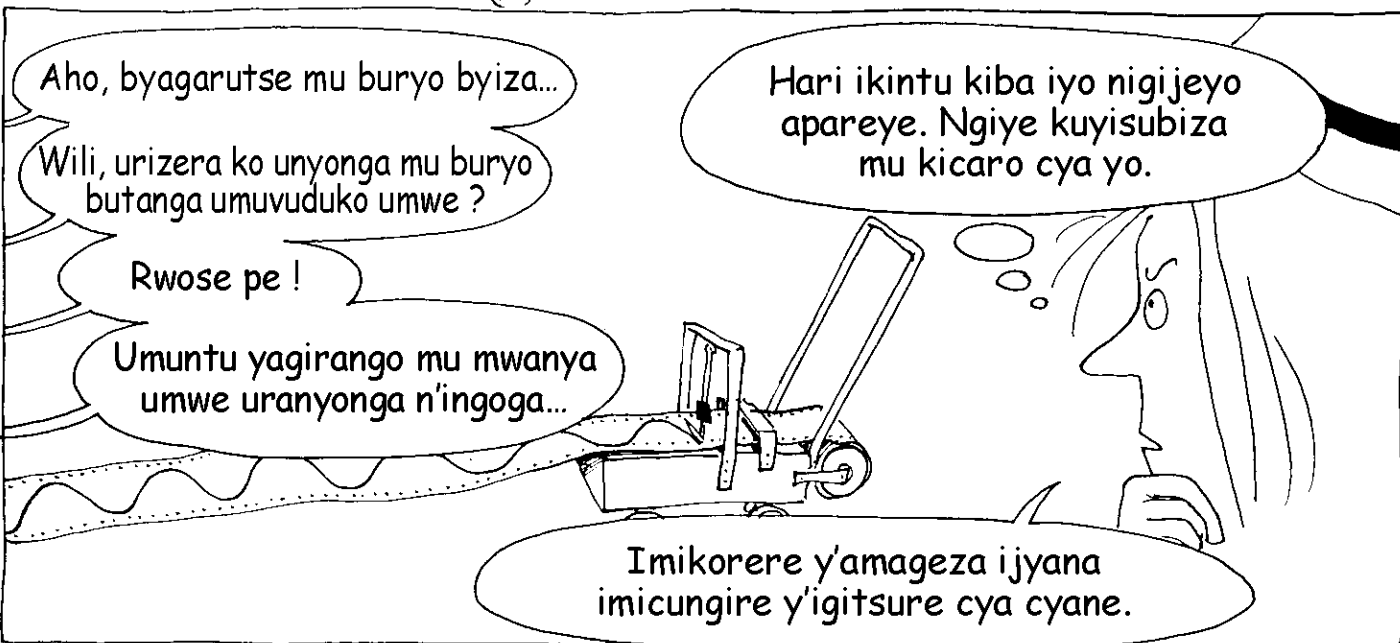
Oya, na busa pe.



He !!! uriho urakora iki ?
urahindura ferekanse ?



Oya, na busa pe.



Aho, byagarutse mu buryo byiza...

Wili, urizera ko unyonga mu buryo
butanga umuvuduko umwe ?

Rwose pe !

Umuntu yagirango mu mwanya
umwe uranyonga n'ingoga...

Hari ikintu kiba iyo nigijeyo
apareye. Ngiye kuyisubiza
mu kicaro cya yo.

Imikorere y'amageza ijyana
imicungire y'igitsure cya cyane.

!!!

Wili, nyonga, yego cyangwa zutu !

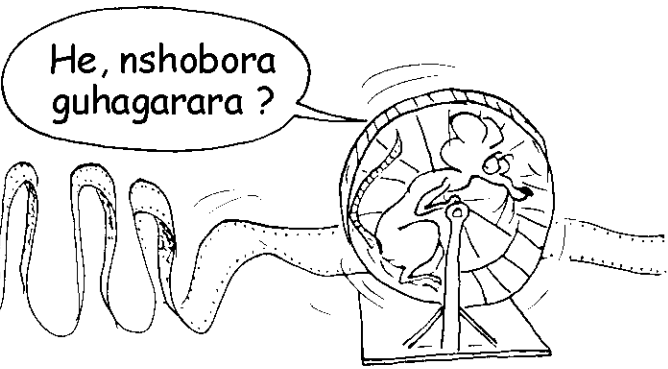
Ariko NDA nyonga !

Nimba mutishimye, mufite kubikora
mu mwanya wanjye !

Ngaho rero basha,
ni munsobanurire ibyanyu.

?


Byagarutse mu buryo nyabyo.
Mu mwanya habaye iyongerwa ry'uburebure
bwa onde (A), ni ukuvuga igabanuka ngaragara rya
furekanse, k'ubwakitiro. Hanyuma, hashize umwanya
ubayabaye (B), twabonye ukwiyongera kwa furekanse,
ku bwakitiro, ni ukuvuga igabanuka ry'uburebure bwa onde λ .




He, nshobora guhagarara ?



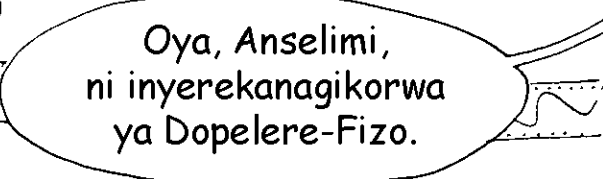
Yego, Wili, hagarara.



Wili avuga ko yagiye anyonga k'umuvuduko umwe.



Yenda ni urupapuro rwikweduye cyangwa rwiyegeje ?





Oya, Anselimi, ni inyerekanagikorwa ya Dopelere-Fizo.



i... iki ?!?

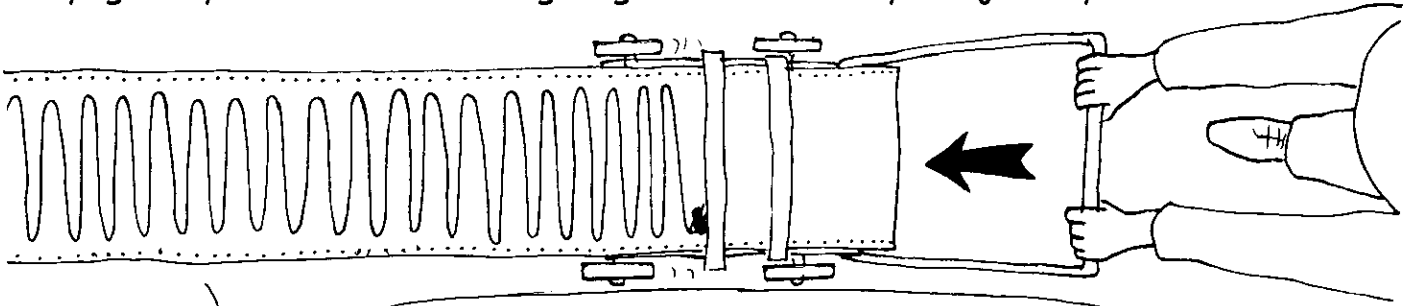


Iyo unyeganyije ikigare, ibyo bihindura furekanse ngaragara.

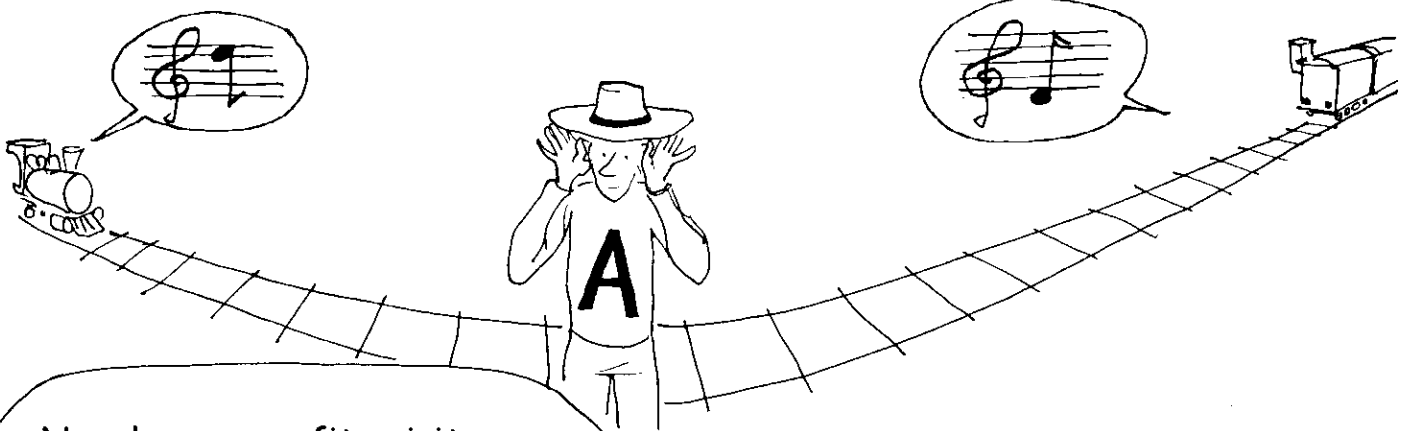


Iyo ikigare kigiye hirya, sinizoyidale irikwedura na furekanse ikagaragara ko ari ntoya cyane.

Iyo ikigare kyigize hino, kyikicuma kuri bande, sinuzoyide iritsindagira, ikiyegeranya na fureka ikagaragara nk'aho ari iyo hejuru cyane.



Ni kimwe neza nk'ibiba iyo wumva ifirimbi ya gariyamoshi iciye imbere yawe. Iyo ikwegera, ijwi ryumvikanira hejuru. naho iyo irenze igenda hirya, ijwi rica bugufi.



Noneho rero, mfite sisiteme nk'iyi, igihe naba nzi, mbere ya byose, uburebure bwa onde y'ikimenyetso kizoherezwa n'isoko iteretse hamwe, nshobora kubara nkabona umuvuduko nyegera cyangwa mpunga (ingarurabibazo) y'isoko.

Kandi ikiba ihame kw'ijwi kinariba k'urumuri. Ibintu biducaho bidusiga bigaragara nk'ibitukura cyane, naho kandi Ibiza bitwegera bigaragara nk'ibisa na bururu cyane.

Byiza, tugaruke kuri ya mageza yacu y'iyohereza butumwa ku hantu h'intera.

Wili, mu mwanya wa we.

Yahinduye furekaanse !?

Cyangwa rero yigiye hirya...

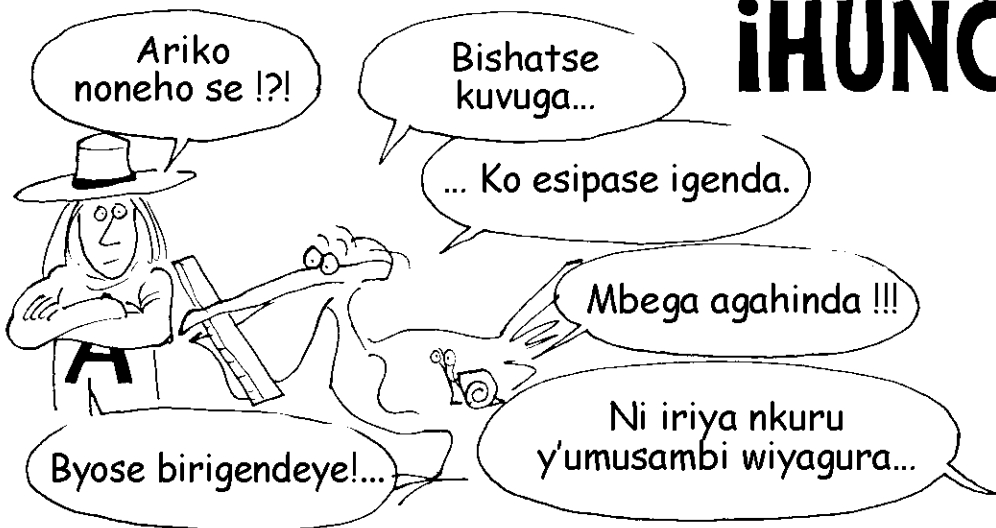
Biratangiye nko mu kanya gashize.

Yego, ni byo ! Agomba n'ubu kwigira hirya.

Oya ariko, mwa bitindi by'ibigoryi, ntaho nagiyeye kuko ndi HANO!...

Na osiyateri yagumye hariya.

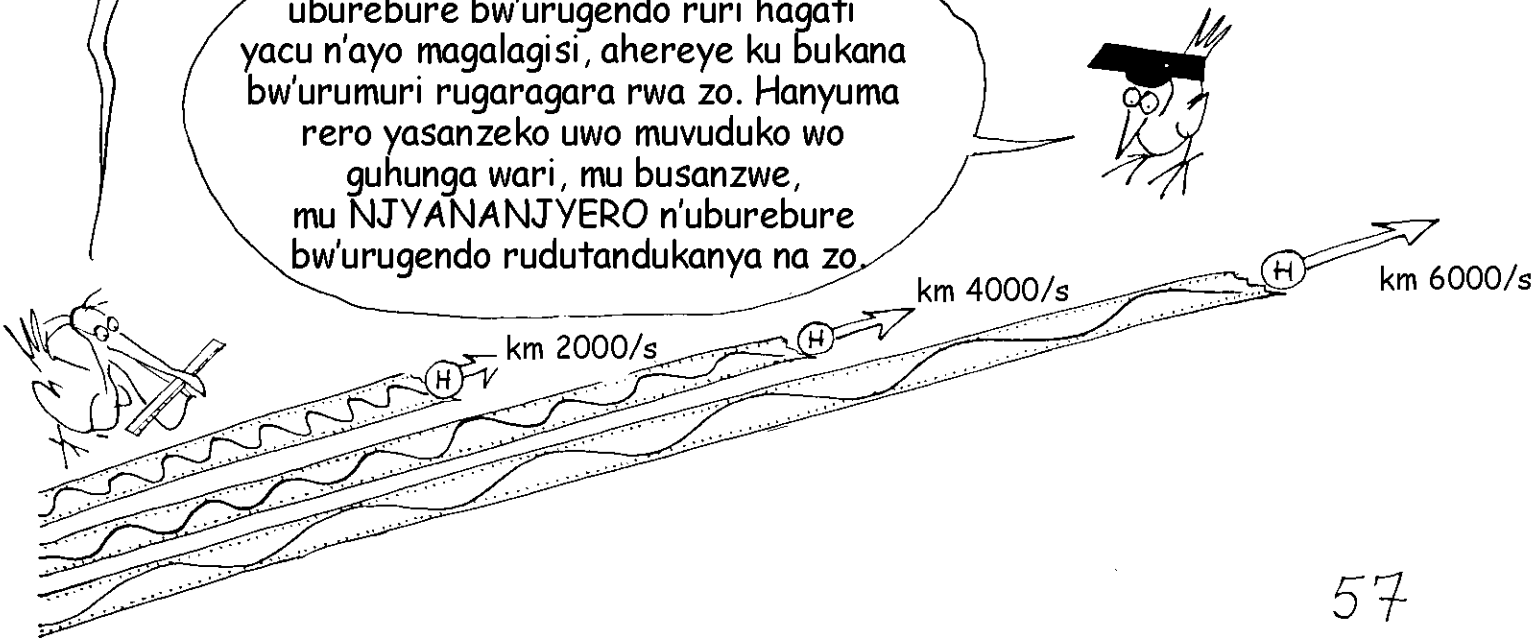
IHUNGA RY'AMA GALAGISI



Ehe yego, ni nk'uko mu 1930, Eduwine Hubble yavumbuye IKWEDUKA RYA INIVERI, avumbura ko za galagisi za kure y'iyacu ziduhunga: hakurikijwe inyerekanagikorwa ya DOPELERI-FIZO, zigenda zihinduka umutuku cyane muri uko kumenengana kwazo ziduhunga.

Ayo m'atome ya hidorojene asakaza, mu by'ukuri, mu uburebure bwa onde bwa cm 21. Inyerekanagikorwa ya Dopeleri inyereka imivuduko yo guhunga ya km 2000/s, 4000, km 6000/s.

Habele ashobora kubara uburebure bw'urugendo ruri hagati yacu n'ayo magalagisi, ahereye ku bukana bw'urumuri rugaragara rwa zo. Hanyuma rero yasanze uwo muvuduko wo guhunga wari, mu busanzwe, mu NJYANANJYERO n'uburebure bw'urugendo rudutandukanya na zo.




Buretse, ibyo se bivuze iki?
Ese ibintu byiyonjyera umuvuduko
uko biduhunga?

Ntabwo aribyo neza. Umusambi
urakweduka urakweduka mu mpande
zose. Fata urugero rw'akadomo A kaba
kari, igihe $t=0$, ku imetero imwe uturutse
aho uri. Nyuma y'iseconde imwe, kazaba
kari ku $m1cm20$. Umuvuduko w'ubuhunzi
wa ko, uzaba rero ari $cm 20/s$.


Muri icyo gihe, akadomo B,
gatuye ubwa mbere na mbere mu $m2$
uvuye iwawe, kazisanga kari mu $m2cm40$
(mu kadomo B') kandi umuvuduko wako,
UGERERANIJE NAWE, ni $cm 40$
kw'iseconde.

Inyerekanagikorwa
ya DOPELERI yerekana
imivuduko njyereranyi.


Nta mpinduka y'uburebure
bwa onde igihe inyohereza majyi hamwe
n'inyakiramajwi zigendera k'umuvuduko
ungana hose ku mihanda iteganye.




Biryo rero Iniveri yacu yose irakweduca ?




Buretse, jyewe mfite ikindi gitekerezo. Reka twemeze ko igihe... kiyongera umuvuduko.



Ariko ibyo... ntacyo bivuze !?!




Imyicundo ya z'atome, akarorero nka z'atome za idorojene, zimeze nku "umusukumamaraso" ya Iniveri. Shyira mu gitekerezo Iniveri ifite umusukumamaraso wiyongera. Rero uko umuntu yaba asaza, ni nako uwo "musukumamaraso" watera n'ingoga. Amashusho y'igihe cyashize atugeraho nka filime yagabanirijwe umuvuduko. Naho inyerekanagikorwa ya Dopeleri yo ni nk'igitekerezondoto.



Yego pe, Tireziyasi, umuntu ashobora gushyira mu gitekerezo ikintu icyaricyo cyose; rero ibyo uvuze bisa no kuvuga ko amategeko ya fizikye ajyana n'igihe, ni byo rero Ferede Hoyile yaragamije.

INDIBA Y'IJURU IRAKONJE



Ariko hari n'iyindi nshyigikira ivugira ubukweduca, hamwe n'inshyigikira ya yo, ariyo BIGI BANGE.

Aha !

Mu kanya gashize, twari twabonye ko I fotoni imwe gusa kuri miliyaridi ariyo yashoboye kwihindura muri matsiyeri.

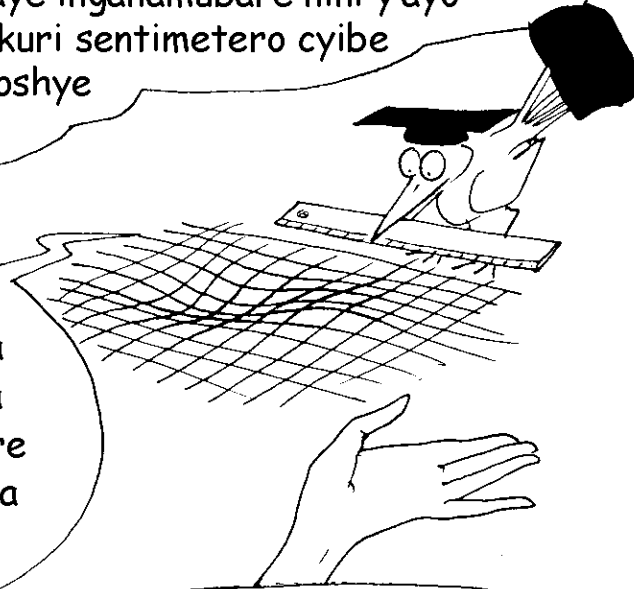


Naho se muri ndwanyamatsiyeri!



Hakabaye rero harasigaye inganamubare nini y'ayo mafotoni y'ibanze, hafi ya 500 kuri sentimetero cyibe (na netirinosi zingana gurtyo, zitoroshye na busa kuvumbura aho ziri).

Uburebure bwa onde bwazo bwagombye kuba bureshya na milimetero eshanu. Ibi bijyana n'igipimo cy'ubushyuhe bw'umurasire T_R bungana na dogere ndashyikirwa eshatu (-270°C)



Izo fotoni, z'ingufu nkye cyane, Peniziyasi na Wilisoni bazibonye mu 1964. Ni ryo vu nyaryo BIG BANG yasize; ni ikimenyetso kigaragara cy'uwo mucezo munini nyakosimosi.



Ahaa !!!

Nguko rero...



IRENGERO RYA KOSIMOSI

Sofi, hakurikijwe IHAME RYA HABELLE,
umuvuduko wo guhunga w'ibintu wiyongera
mu rwego rumwe n'uburebure...



Rero, mu by'ukuri,
hagomba kuba hari ibintu byigirahirya
yacu ku mivuduko ingana cyangwa isumba
umuvuduko w'urumuri !?

Biryo rero,
birumvikana ko tutaba
tukibonye urwo rumuri
bitwoherereza ?!



Kubera iki?
Niba indege igenda yegera hirya
yacu k'umuvuduko uruta uw'ijwi,
nshobora ibyaribyo byose,
kumva ijwi ryayo, sibyo se ?



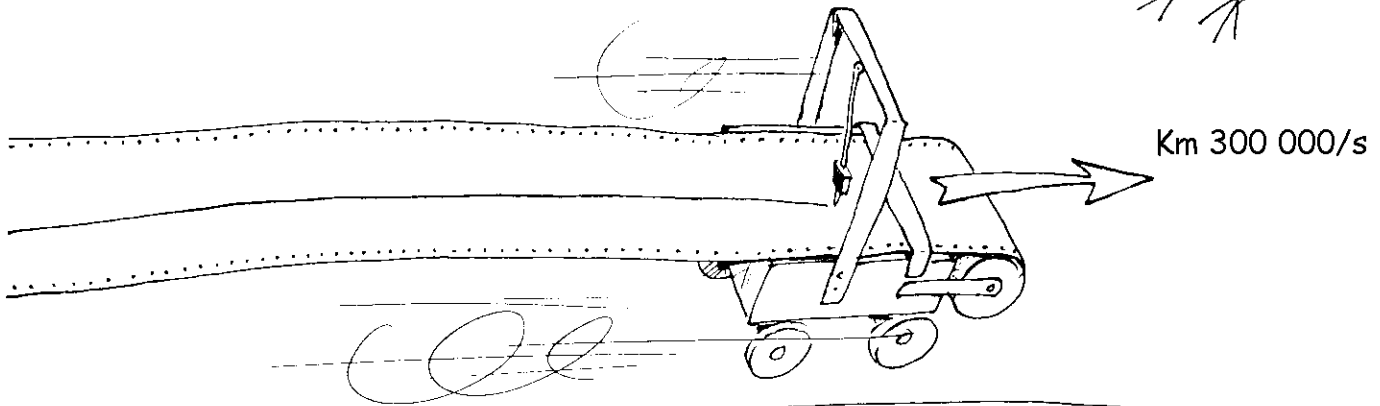
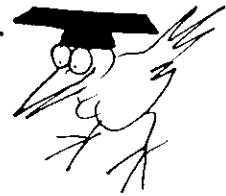
Nshuti zanjye,
si uko mugomba
kureba ibintu.



Igikorwa cyo kugenda kigira ingaruka ku GIHE (*).
Ikintu kigenda k'umuvuduko wegera km 300 000 /s,
k'umuvuduko w'urumuri, kiba kiri, uhereye aha turi ubu,
twebwe nk'indorerezi, mu " mubumbe w'igihe"
utandukanye n'uwacu. Tubona ubutumwa bwe
nk'ubwoko bwa filime igenda buhoro bidasanze,
yomboka.



Naho kandi iyo icyo kintu kigenda, ugereranije natwe,
k'umuvuduko w'urumuri, amayobera y'igihe aba yose.
Igihe cyo gisa ni ikitagenda nk'isosi mu nkono.



Kubera ubwo bunyerere, ayo mayobera y'ibihe
kimwe kigereranijwe n'ikindi, furekanse y'ama onde,
ku cyacyiriro, iragabanuka. Noneho kandi iyo
fenomene, nyarolativite, iza kwigereka hejuru,
kwiyongera ku nyerekanagikorwa ya DOPELERI.
Igihe umuvuduko wo guhunga kw'insakazamawonde,
utangiriye aho turi, unganye na c, furekanse y'ama
onde yakiriwe ingana na zero. Icyo gihe
nta ngufu, nta onde, nta butumwa !

Imiraba ya furekanse ingana n'ubusa,
ntabwo iba ikiri imiraba!

(*) reba IBINTU BYOSE BIFITANYE ISANO, by'umwanditsi umwe, icapiro BELINE.

Ku byerekeye ibintu bidukikiye, umuvuduko nyarolativite ungana na km 300 000 /s ugerwaho kuri siferi bita IRENGERO. Ntabwo ari urubibi RY'IBINTU BIBAHO ahubwo ni urubibi ry'IBINTU DUSHOBORA KUMENYA. Iniveri dushobora kubona ishobora kuba ari agace ka iniveri nini cyane. Iryo rengero riri kuri miliyaridi cumi z'imyaka-rumuri. Magingo aya, intera ya telesikope yo kw'isi ya mbere ireba kure, PALOMARI, ingana na miliyaridi imwe y'imyaka-rumuri.

Ubuyobozi.

Ariko se, mu kanya gashize, iyo reyo R ya Iniveri yashakaga kuvuga iki ?



Amateka yatangiye igihe Iniveri yari ifite kimwe kw'ijana cy'isogonde. Tekereza rero ko icyo gihe hari kuba hari umuntu waciye serikyeri, byiza cyangwa siferi, ya reyo R ahantu noneho tukaba dukurikirana ikweduka ry'iyu sefiri mfatizo muri iki gihe cyose. Nguko uko bimeze...

Naho ibyo byaba byarakozwe, ntacyatuma twemeza ko esipase ishobora kuba ifite ubungane bubarika cyangwa bunini cyane kandi butabarika(*)

He, mwebwe babiri !

Afite amaso y'itekye


Iyi nyandiko nshushanyi ntirangiye !

HiHiHi

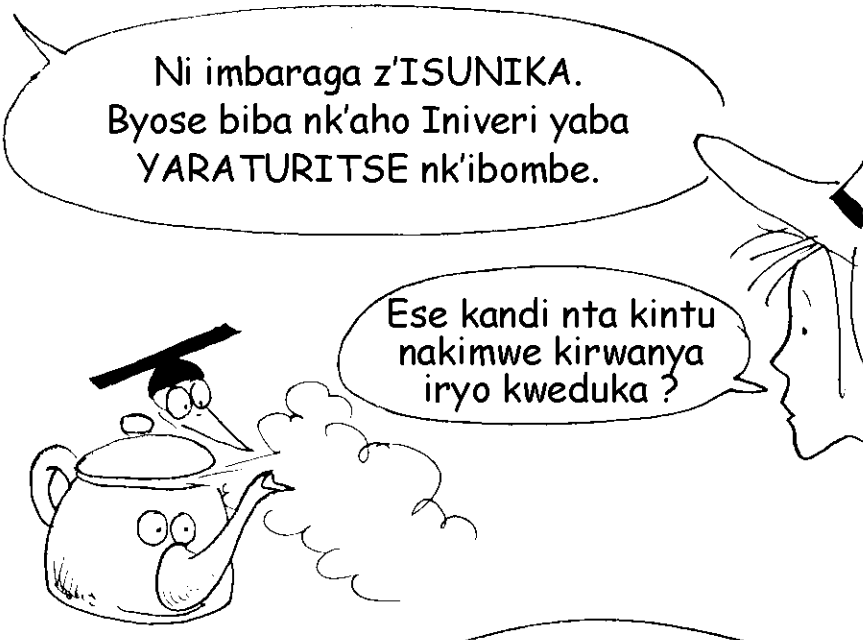
Turacyagukeneye kandi

(*) kuri icyo ngingo, reba JEWOMETIRIKONI, umwanditsi ni umwe, icapiro Belini.

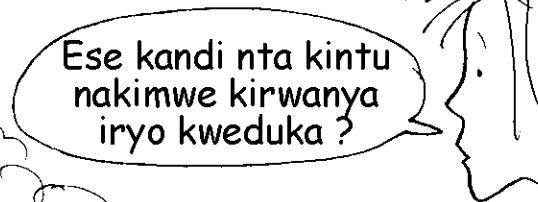
MODELİ ZA FIRİDİMANİ




Sofiya, ni iki gitera ikweduca rya Iniveri ?




Ni imbaraga z'ISUNIKA. Byose biba nk'aho Iniveri yaba YARATURITSE nk'ibombe.




Ese kandi nta kintu nakimwe kirwanya iryo kweduca ?



Imbaraga karemanorukuruzi zihora zikora k'uburyo Iniveri yiyegeranya, IGAHOBANA.



Ese ntabwo umuntu yatekereza Iniveri iteye k'uburyo izo mbaraga sunika na karemanorukuruzi zigwa miswi?



Dushobora kwerekana ko iryo gwamiswi ridashoboka. Riramutse rihushiye ho gato iyo iniveri "idahinduka" yahombana burundu cyangwa igaturika.

Iturika



Ihombana

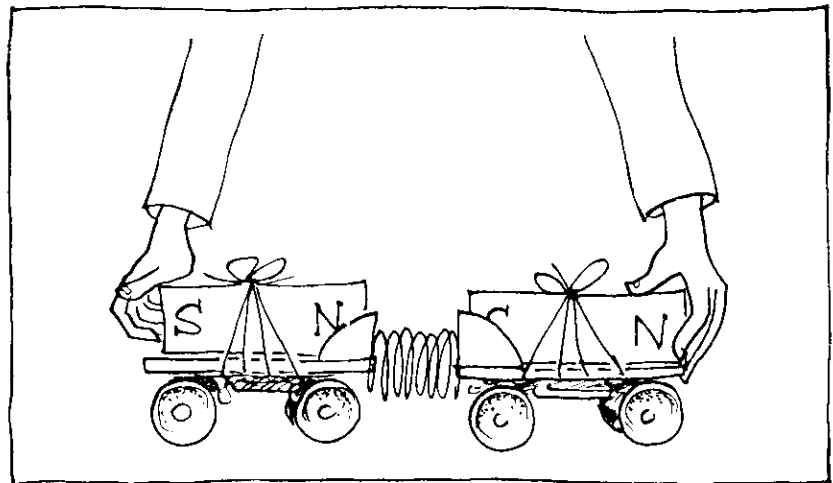
None se, cyo mbwira, Iniveri yacu yari gushobora.... Guhombana aho guturika?

Mu nzira imwe, ni amahirwe...

Ni iki kikubwira ko igihe, cyo, kitari kugenda ... gisubira inyuma....



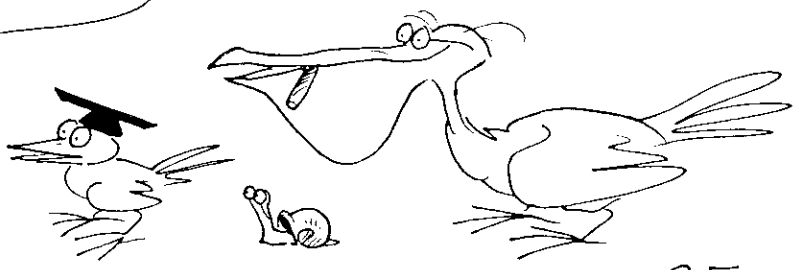
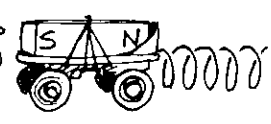
Tisisisi!...

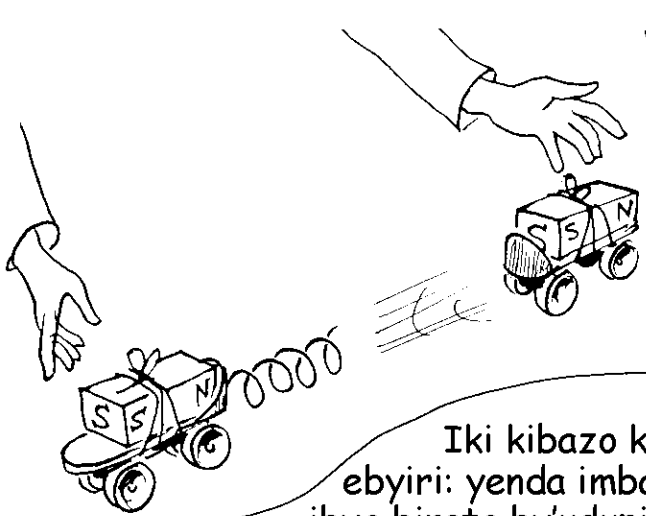


Anselimi yashumitse sumaku ebyiri ku birato by'udupine munsu. Birakururana. Ariko rosoru itsindagiye igenda ishaka kubitandukanya yigizayo imwe ku ruhande rumwe n'ikindi k'urundi.



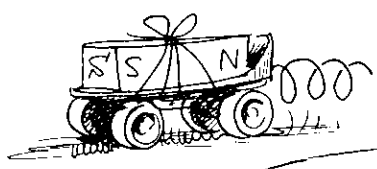
Urabibona, izi sumaku zigereranwa n'imbaraga karemanonkuruzi, nkuruzi, ziganisha hamwe. Rosoru igereranywa n'imbaraga sunika.





Iyo nzishumukuye,
ibyo birato b'udupine
mu nsi bijugunwa kimwe
kure y'ikindi.

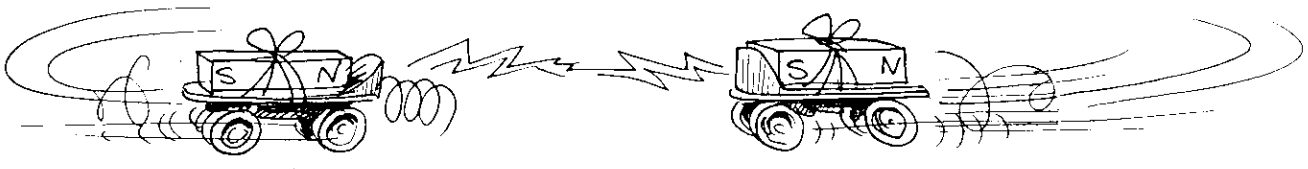
Iki kibazo kigaragaza impande
ebyiri: yenda imbaraga-sunika zahawe
ibyo birato by'udupine ni nyinshi cyane,
ubwo rero ibyo birato bizahita bitandukana kimwe
gikomeze guhunga ikindi ubuziraherezo. Uko bizagenda
bihungana ni nako imbaraga z'ikururana, zihinduka mu
ncurikaburyo ya kare y'uburebure, zizagenda
zigabanuka.



Nimba nta tsirimana rihari, ibyo birato by'udupine mu nsi
bizaruhira kugira UMUVUDUKO UMWE UDAHINDUKA.

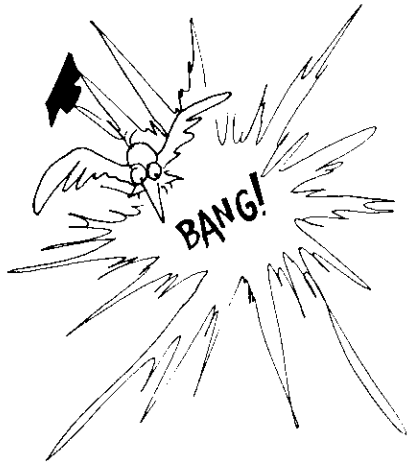


Cyangwa rero imbaraga-sunika zatazwe
na rosoru ni nto cyane, cyangwa za sumaku
zirakomeye cyane. Bya birato by'udupine
bizagaruka, "bigwe" kimwe ku kindi,
k'umuvuduko wiyongera.

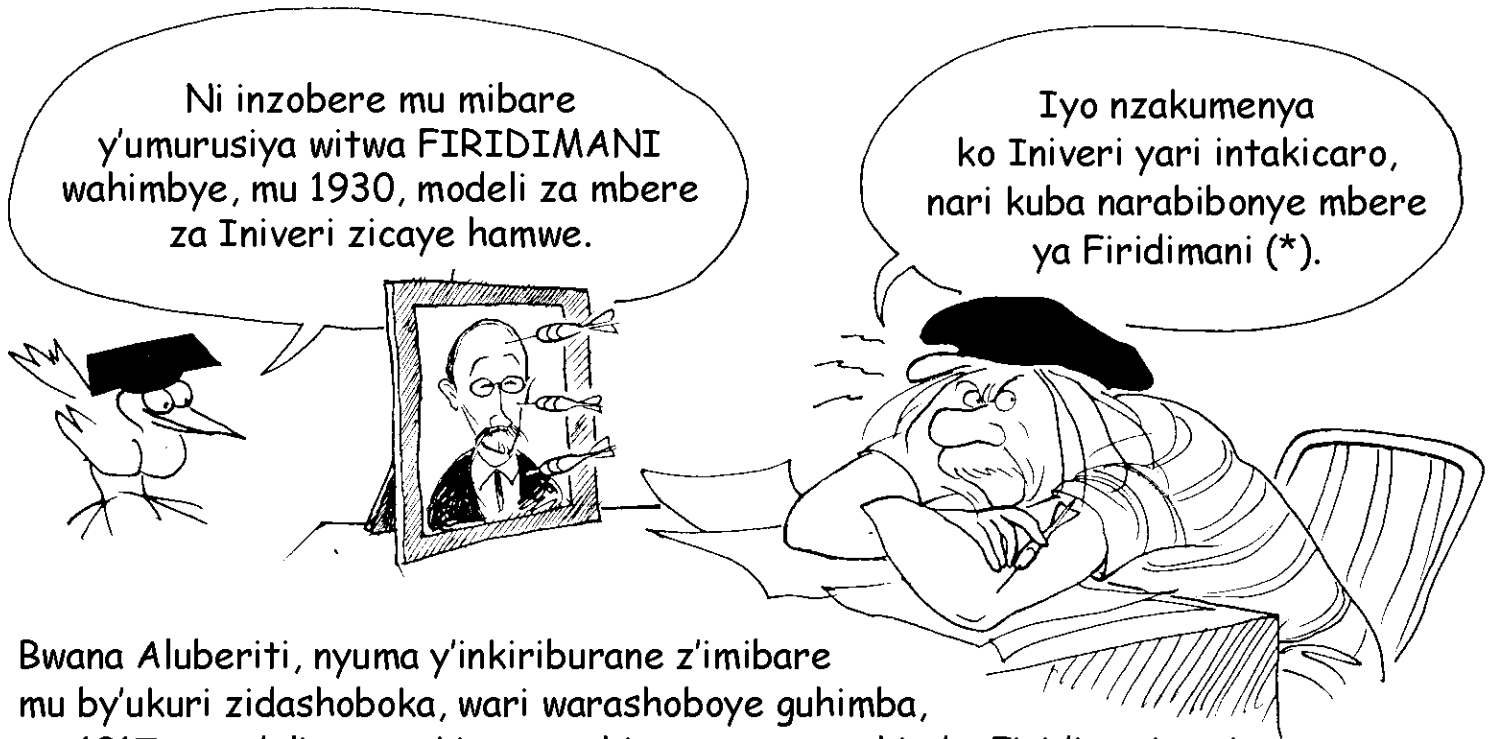


Ibi bitera gutekereza ko hariho ubwoko bubiri bushoboka bwa Iniveri:

Intekerezo ya mbere: ikweduka rirakomeza ububuraherezo. Igihe inyenyeri
za nyuma zizazimira, hazaba ijoro rihoraho, ubukonje buhebuje,
URUPFU RW'UBUSHYUHE.



Intekerezo ya kabiri: imbaraga karemanorukuruzi zigeraho zigatsinda. Nyuma y'ikweduka rinini ry'umurengera, Iniveri " izagaruka yigweho ubwayo". Imitererempagaze yose, za galagisi, inyenyeri, bizaturika. Ama atome ubwayo azakonjwakonjwa. Birtyo hazabaho Bigi Bange mu ncurikaburyo, kugezaho irindi zamuka rya Iniveri riba, iyindi ntera nshya y'ikweduka.



Ni inzobere mu mibare y'umurusiya witwa FIRIDIMANI wahimbye, mu 1930, modeli za mbere za Iniveri zicaye hamwe.

Iyo nzakumenya ko Iniveri yari intakicaro, nari kuba narabibonye mbere ya Firidimani (*).

Bwana Aluberiti, nyuma y'inkiriburane z'imibare mu by'ukuri zidashoboka, wari warashoboye guhimba, mu 1917, umudeli we nyakicaro, yahise agwa mu gahinda. Firidimani yari yamurushije kuba ikirangirire. Bwana Aluberiti yahise ashyira iruhande rolativite rusange igihe cy'imyaka mwinshi.



Dukurikije ama modeli ya Firidimani, Iniveri iri mw'ikweduka ritagira iherezho nimba indemere (ya magingo aya) ya matsiyeri iri muni ya garama 5.10-30 kuri sentimetero kyibe. Iyo Iniveri kandi yaba ifite volime, n'inkweduke nyayesipase itagira iherezho.

(*). Ikyibutso nyacyo cya Eyinishiteyini.

JEWOMETIRI (YA/ZA) INIVERI

Iniveri, kuri twebwe, ni indengamitererempagaze ya dimansiyo ennye, aho esipase n'igihe byivanga. Ibitekerezo byavuzwe mu mapaje twarenze bihwanye, kimwe cyose, n'inyerekanyi inyuranye y'iyi INIVERI-TSINDA ariyo ESIPASE-GIHE.

Iniveri ...
ifite iforoma
yihe ?

Ibyago...

Twibukeko umubare
wa dimansiyo za esipase ari umubare
w'inganamubare zihagiye kugirango
usobanure ikicaro cy'akadomo.

Randevu (1) ku wakabiri saa tanu ku mfuruka
y' (2) umuhanda wa gatandatu n'agahanda (3) ka gatanu
kuri (4) etage ya gatatu: amatsinda ane.

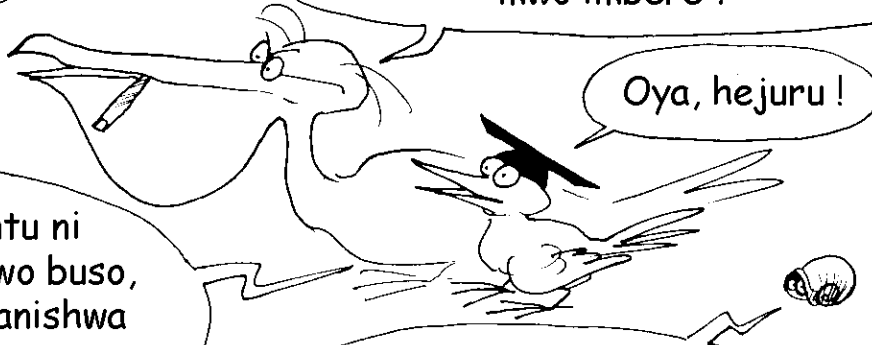
Ku gishushanyo, dushobora
gusa kwerekana za esipase za
dimansiyo EBYIRI, INYABUSO.
Rero tugiye kwiga esipase-gihe
ya dimansiyo 2, imwe ni iy'ikicaro
naho indi, ni igihe.

Igihe
ikicaro

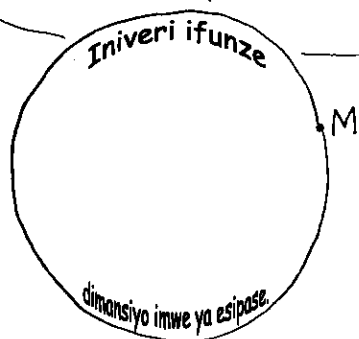


Biryo modeli y'ambere yaza Iniveri zifunze, modeli iri hamwe ya Eyishiteyini ishobora kwiyerekana hakurikijwe silinderi.

Buretse, nimba numvise neza, iyi silinderi, tuyirimwo... mwo imbere ?



Ku gihe runaka, ikintu ni ako kadomo M kuri ubwo buso, kandi Iniveri yose inganishwa n'iyi cercle.

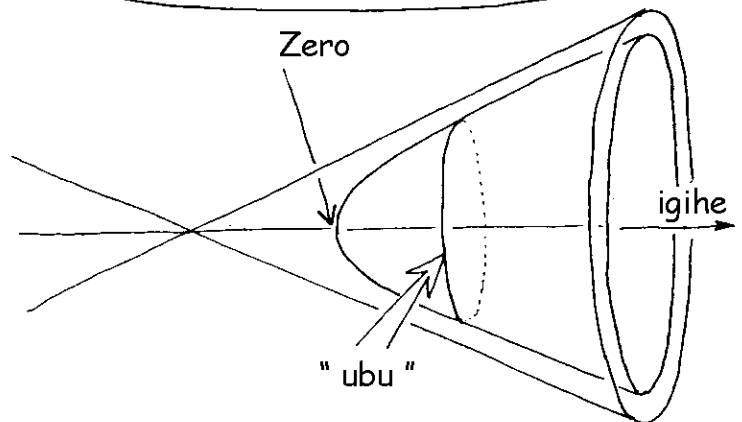


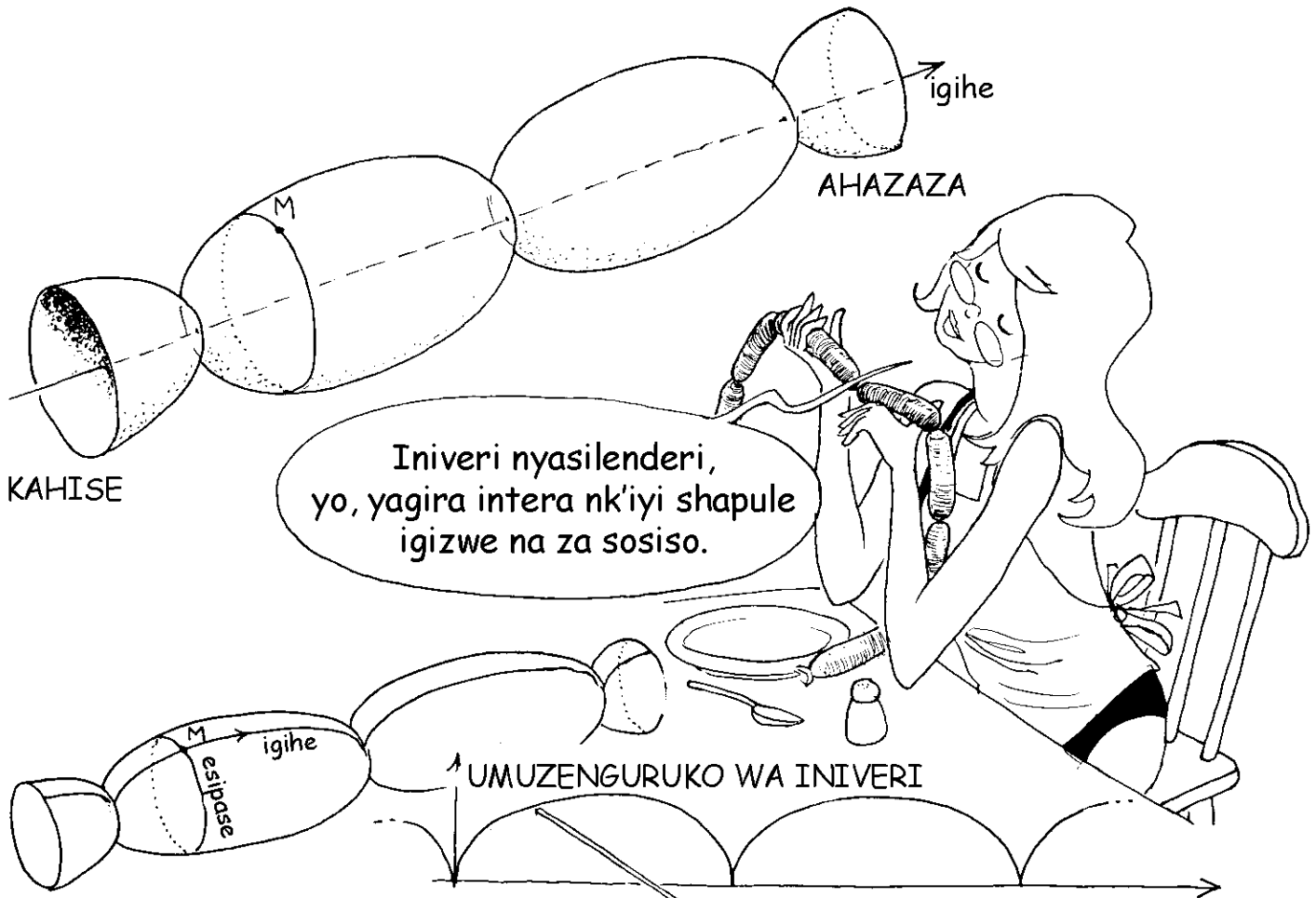
Iyo ikintu gihamye hamwe, kiba gishushanya jeneratirise ya silinderi, mu mwanya w'igihe.



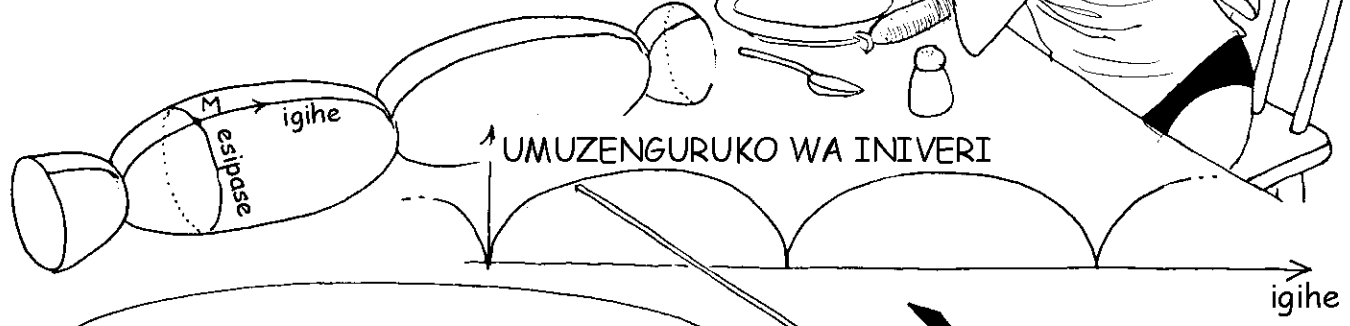
Biroroshye kwerekana ikweduka ry'iyi iniveri ifunze mu nkurikiranazira y'igihe, ibyo bitanga modeli ya iniveri ntakicaro.

Dore, nk'urugero, ishusho muri dimansiyo ebyiri ya espase-gihe mw'ikweduka mburaherezo.

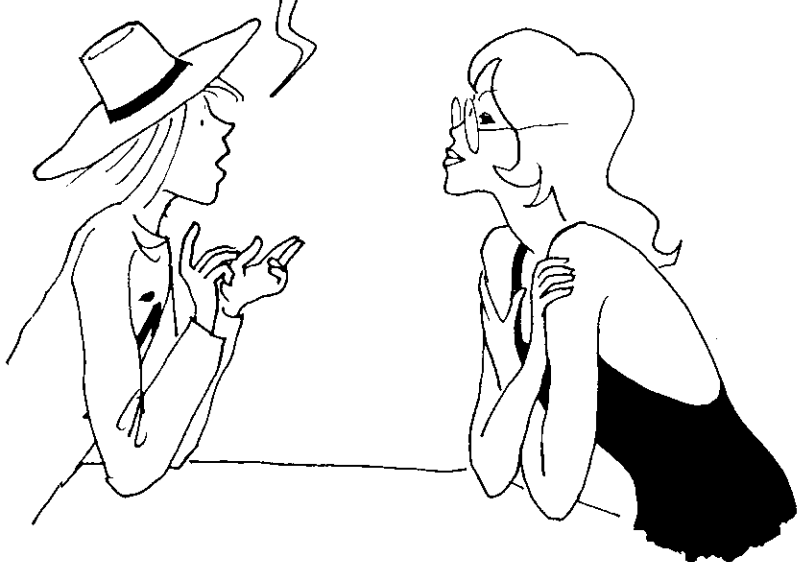
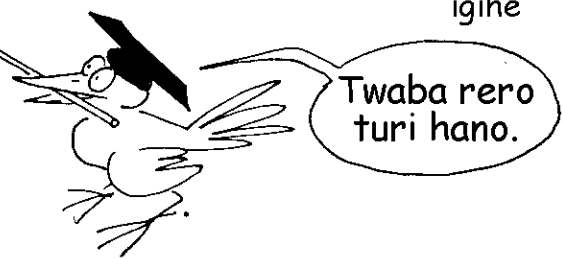




Iniveri nyasilenderi,
yo, yagira intera nk'iyi shapule
igizwe na za sosiso.



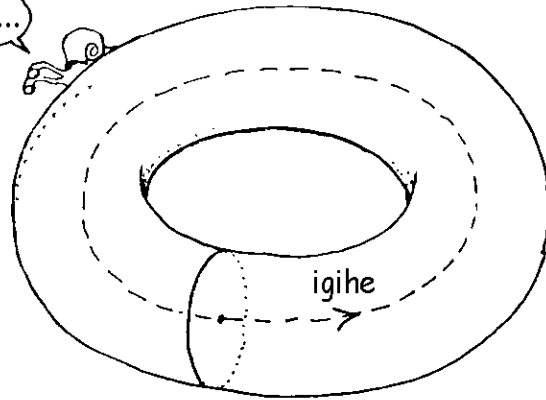
Ariko se, mu by'ukuri, kuki igihe,
byaba ngombwa, ko kiba "GIFUNGUYE"
, ni ukuvuga ko kitagira iherezo
waba ugana mu ahazaza no mu
gihe cyashize ?



Murashaka kuvuga
ko bishoboka ko... igihe
gifungwa uhujije imitwe
ya cyo !?!

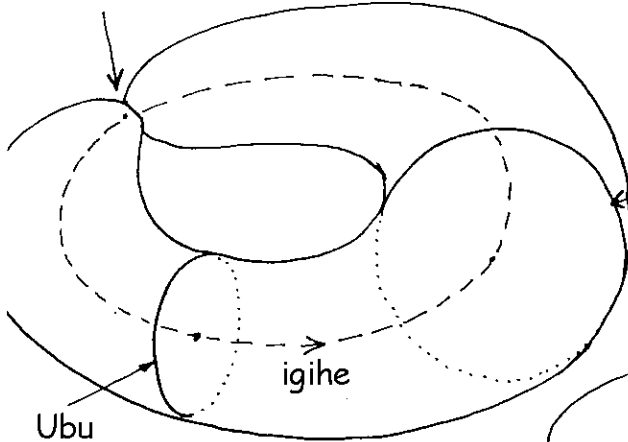
Nta kibazo ...
turamutse dufunze modeli
ya Eyinshiteyini duhujiye
imitwe ya yo, twabona...
INGATA.

Kandi se !...



Muri icyo ESIPASE-GIHE ifunze rwose,
evenoma zimwe ziba mu rukurikirane ruhora rugaruka rusa
kwakundi nyuma y'igice cy'umwanya ari cyo bita PERIYODE
y'icyo nteramatsiko ya iniveri .

Inyakimwe BIGI BANGE



Birashoboka ko iniveri
nsubirahoyahoze yakwizinga
igahuza imitwe.

ikicarorugendo
cy'ikweduka muherezo.

Bhinduka ishapule ya za sosiso,
yifungiyeho ubwayo, igizwe n'isosiso imwe !

Ya payutse,
byari byitezwe.

Ohu, reba Lewo !!!



INGANAMUSOZO

Dore ibyo tuzi
ku ntangiro ya Iniveri



Mu gusoza...
ibyo **TWIBWIRAKO TUZI.**
Byarahindutse inshuro
nyinshi kuva imyaka 5000 !

"Ariko icyo gikorwa
mpurizwaho rusangi kugirango
dusobanukirwe Iniveri icyo aricyo, ni kimwe
mu bintu mbarwa biha ikuzo ubuzima-muntu
bukarengera inkinamico yo muri iyi si, bikana
buha agaciro na gacye muri aya makuba
twiberamwo."

Gitefano Weyiniberige




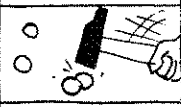

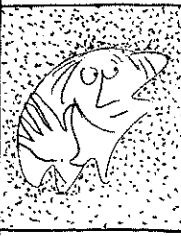
Ibikurikira **BIG BANG** (iremwa ry'amagalagisi, ry'inenyeri,
n'ibindi n'ibindi...) murebe mu **MAZUBA IGIHUMBI**

UMUSOZO



KOSIMOSI NYAMAHAHO



IGIHE	IGIPIMO CY'UBUSHYUHE	INDEMERE	FENOMENE
MBERE YA ..	$T \geq \text{dogere } 10^{12}$?
1/1000 cy'i seconde	Dogere miliyalidi 300		Igikoma cy'imvanyye ya za fotoni, netirinosi, ndwanyanetirinosi (fotoni yo ni yo ubwa yo ndwanyaparitikile ya yo) ya za porotoni, ya za ndwanyaporotoni, y'ama elegitoroni na ndwanya-elegitoroni (pozitoroni).
1/100 cy'iseconde	Dogere miliyalidi 100	Miliyalidi 4 za g/cm^3	Irigita-honero rya za hadoroni (porotoni, ndwanyaporotoni, netirinosi, antinetirinosi). Hazasigara imwe rukumbi kuri buri miliyalidi imwe. Ibindi byahoneye hamwe na za ndwanyahadoroni z'icyo gihe, kugirango bitange ama fotoni.
1/10 cy'i seconde	Dogere miliyaridi 30		Nta cyo gutangaza. birashyushye bikabije kuburyo nta za nuwayo z'atome zakirema.
Segonde 1	Dogere miliyaridi 10	g/cm^3 380 000	Za netirinosi " zibaho mu buzima bwazo". Zireka kugira imihurirebikorwa na matsiyeri.
Segonde 13	Dogere miliyaridi 3		Irigita-honero rya za elegitoroni- ndwanya-elegitoroni. Aho naho hazasigara, imwe kuri miliyaridi imwe.
Iminota 3	Dogere miliyali 1		Iremwa rya nikeleyoni: iremwa za nikeleyoni za Eliyomu. Irigita rya za netoroni zigenga (uburambe bw'ubuzima: ama seconde 109)
Iminota 35	Dogere miliyoni 300	$\sim \text{g/cm}^3$	Iremwa rya nikeleyoni riba rirarangiyeye: 25 % ya Eliyomu, 75% ya Idorojene.
700,000 yr	Dogere 3000.		Nyuma y'ihonero rya matsiyeri na ndwanyamatsiyeri nka byose, Iniveri yabaye mu "bihe nyamurasire", aho itsinda ngufu-matsiyeri byabaye ku bwinshi mu foroma murasire. Igihe igipimo cy'ubushyuhe kimanutse kikagyera kuri dogere 3000, ama atome ntagiramashanyarazi yahise akorwa noneho za fotoni zireka imihurirebikorwa na matsiyeri: Iniveri itangira noneho "kubonerana".
Imyaka miliyoni 100	$T_R = -173^\circ \text{C}$ $T_m = -276^\circ \text{C}$		Kuko zitari zigishyushya na za fotoni, atome za idorojene n'iza eliyomu zitagira amashanyarazi zagiye kubona zibona igipimo cy'ubushyuhe bwa zo kiriho kiragabanuka n'ingoga. Bihita bibyara iremwa z'ama galagisi n'inyenyeri za mbere.
Imyaka miliyaridi 5			Iremwa ry'umubumbe w'isi
Imyaka miliyari 10	$T_R = -270^\circ \text{C}$	10^{-30}g/cm^3	Itunguka ry'ubuzima
Uyu muni			Ivumburwa rya bombe atomikye....