

INGYENDO NSHAKISHA
Z'ANSELI
LANTURULU



MU BURYO BW'IMBARAGA ZANYU

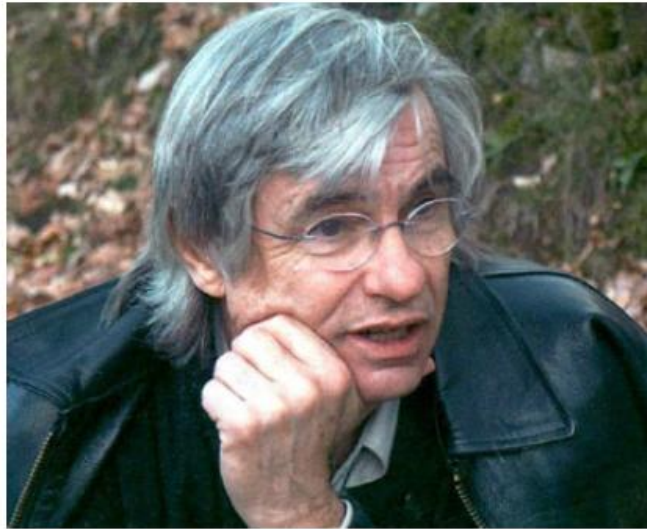
Byanditzwe na Yohani-Petero Petit

Byahinduwe na
Mohamed Abdel Aziz Kamanzi



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 uburya 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.

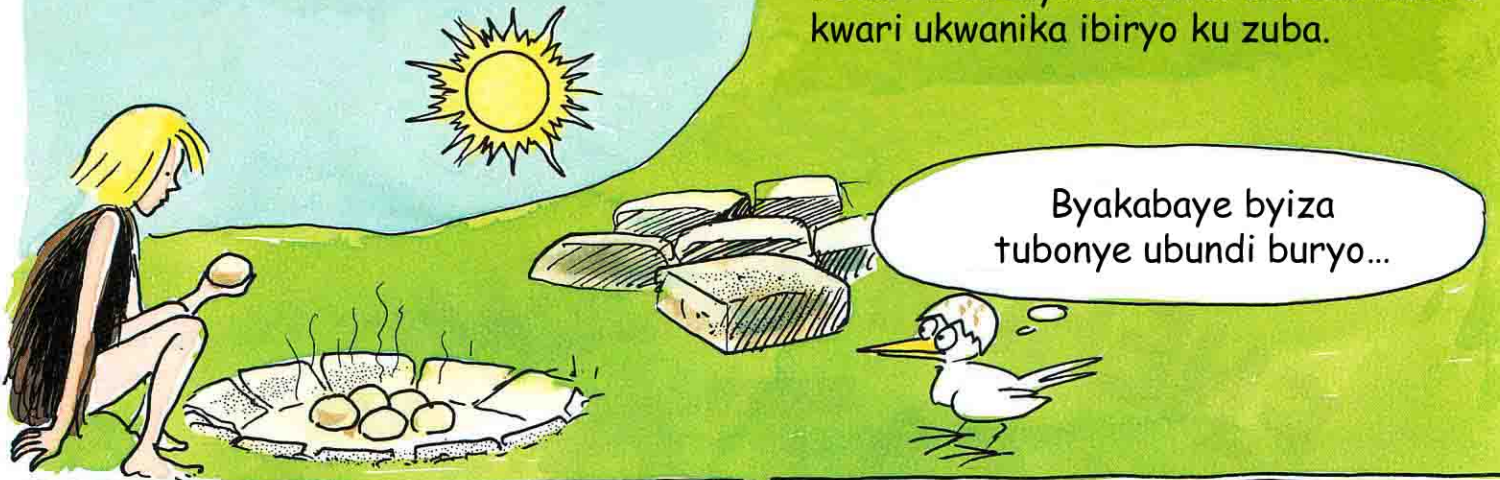
Abanyamuryango ubwabo nibo barihira amafaranga ishyirahamwe rikoresha ngo ribeho nk'ayo kwishyura no gukoresha urubuga rwa yo rwo kuri interineti kuko ayo atarihwa n'ishyirahamwe.

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

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

IMBANZIRIZANKURU

Cyera, kw'isi, habayeho ibihe abantu batari bamenya umuriro. Guteka kwabo kwari ukwanika ibiryo ku zuba.



Byakabaye byiza tubonye ubundi buryo...



Iyo ijoro ryagwaga, binjizaga mu mazu yabo amabuye aremereye, yabaga yabitse ubushyuhe bw'izuba.

... birica...



Uraryanye ?

Oya, amabuye yamaze gukonja...

Ndatitira...

Igihe iveri izazira, bizaba bibi cyane. Kimwe cya kabiri cy'umuryango cyamaze kurwara ibicurane.



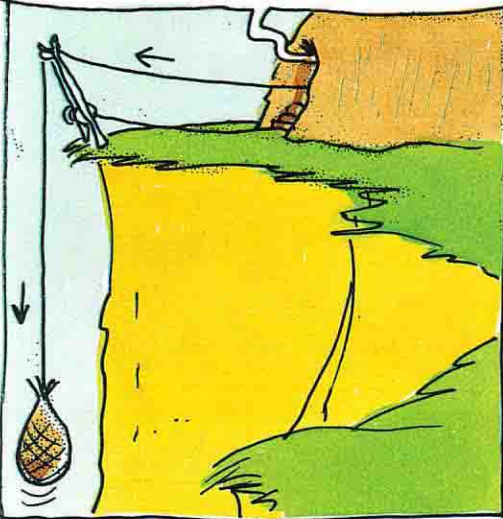
Uriho urakora iki ?

Ndashaka uburyo bwo **KUBIKA IMBARAGA.**

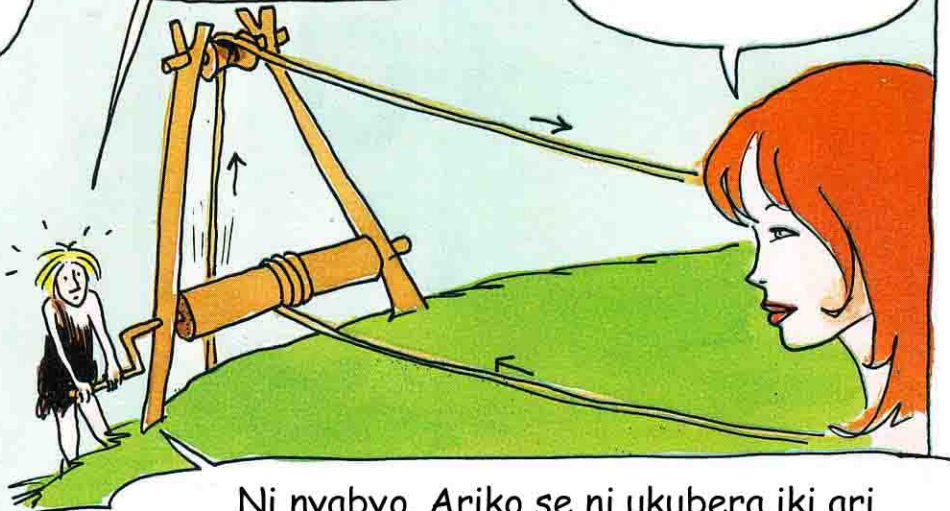


Mu by'ukuri birananiza guhora winjiza vuba vuba aya mabuye mu nzu, buri kigoroba.

Biryo rero natekereje
sisiteme yo gukurura iyo palato
yuzuye amabuye ashushye,
ikayinjiza mu buvumo,
buri kigoroba.



Naho, kumanwa,
nsohora uwo musigo
wa nje.



Ubika
IMBARAGA
NYAPOTANSIYELI.

Ni nyabyo. Ariko se ni ukubera iki ari
twebwe duhora dukora uwo **MURIMO** ?

Uriho urakora iki,
Anselimi ?

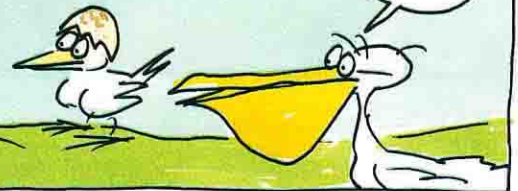


Ndanononsora uburyo bwanjye
by'**IBIKWA RY'YMBARAGA.**

Dore !



Urashaka
kuvuga ko wabitse
imbaraga **IMBERE** muri
aka gasanduka ?



Sisiteme navumbuye
igaragaza ibikwa ry'**IMBARAGA**
Z'IMBERE



Imbaraga nshobora
GUTWARA kandi **NKONGERA**
GUKORESHA uko nshatse.

AAAAHHH



IMBARAGA NYASHIMIKYE

Sofiya!
gusa ryari IBIKWA
RY'IMBARAGA
Z'IMBERE!



Ngiye kugira isuku mu buvumo.
Turebe, salupeteri, sufure...

Naho aya makara
y'ibiti, ibisigarira
by'inkongi y'ishyamba
yatewe n'Imana Nkuba.



Bigomba kuba ibi neza,
naho ubundi Sofiya
aranyica!



... kandi ririya
buye rinini



BUMU!

Sofiya! Navumbuye!
harimwo **IMBARAGA** muri iyi **FU**
YIRABURA maze kuvumbura



Tugiye kujya
tuyikoresha mu guteka ibiryo
no mu kwishyusha!

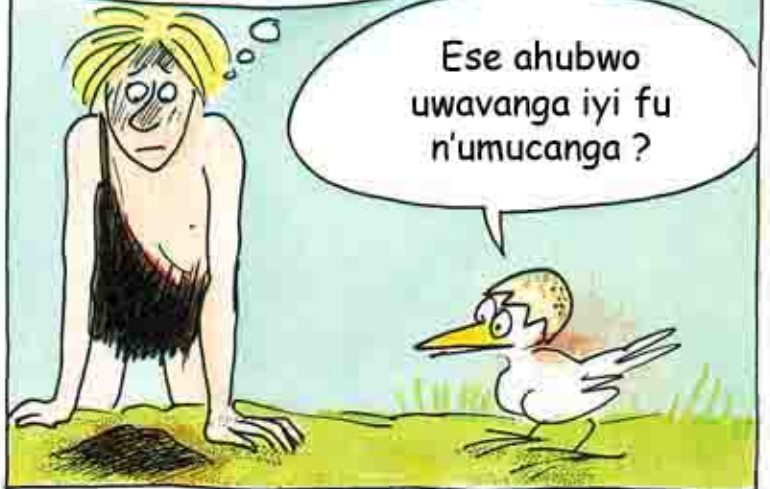


Uzaba ureba...

Nimba ushaka igitekerezo cya nje,
ni ivumburwa ryiza, ariko ntabwo
byoroshye kuyikoresha.



Nagombye se
kubiyhorera?



Ese ahubwo
uwavanga iyi fu
n'umucanga?

Bikora neza !!!
umucanga ucubya iyo mvangye,
ikarekura imbaraga buhoro buhoro!



Isohoka
ry'ubushyuhe rishobora
gukurikiranwa.

Ntabwo tuzasubira kwicwa
n'imbeho muri iyi iveri...



Biratanga ubushyuhe bwinshi, ariko kandi dufite ikibazo cyo guhumeka.



Umuntu yahagwa, ni cyo ushatse kuvuga !



Dore. Ubitse umwotsi muri kiriya gifuko, byagenda neza kurutaho.

Ukonja uhinduka ivu, nshobora rero kuwikiza.



Ni byiza. Ariko ntabwo bikataje cyane...



Nta buryo bwoguta ibyo ahariho hose. Naho ubundi naroga amazi y'ikiyaga.

IMBARAGA NYANIKYELEYERI

Dore, ni amayobera. Amazi y'iri soko arabira.



Imbaraga nyabushuhe ziva he ?

Haba hari amagini munsu y'ubuso bw'isi ?



... utubuwate, hamwe n'amajyini imbere !?



Umugani uvuga ko, cyera, **IMBARAGA** zafungirwa mu ma **NUWAYO** y'ama **ATOME** amwe nk'aya **IRANIYOMU**. Aya m'atome yakorewe mu mazuba, mu matanure yayo, hanyuma akajugunywa hanyuma akanafungirwa muri mase y'Isi igihe cy'iremwa rya yo.

Ariko izo atome ntabwo ari ama buwate akomeye. Kandi, rimwe na rimwe, umupfundikizo wivanaho.



Umugani uvuga ko **IGIHE CY'IMPERUKA**, ama jyini yose azaba yavuye mu tubuwate kandi Iniveri ntizaba igifite imbaraga z'ubwo bwoko.



Hanyuma izihombanya nk'uruhago rw'ingurube.

Ariko ibyo bizamara igihe kinini, igihe kinini cyane...



Nonese, aya majyini aguma mu tubuwate twayo igihe kingana gite? Ese ayo **MANUWAYO** agumana izo **MBARAGA** atunze igihe kingana gite?



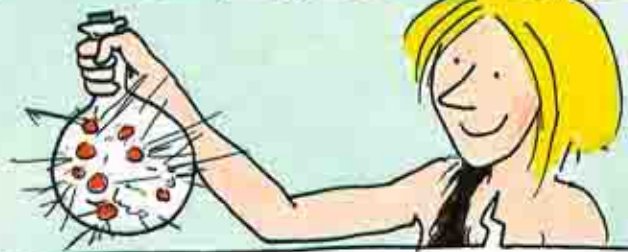
PERIYODE Y'AKAGINGO RADIYOBUKANA

Dufashe itsinda ry'utubuwate turimwo amajyini, nyuma y'igihe runaka T kitwa ICYAKABIRI-BUZIMA cyangwa PERIYODE, KIMWE CYA KABIRI cy'utubuwate twaba twarekuye ama jyini ya two. Mu mwanya w'igihe ungana, kimwe cya kabiri cy'utubuwate twasigaye tuzifungura natwo. Hanyuma bikomeze bigenda birtyo. Icyo cyakabiri-buzima gishobora guhinduka : miliyaridi y'imyaka cyangwa ibice by'isogonde.



Kandi, iyo hataza kubaho ubwo bubuwate bwose hamwe n'ijyini zatwo, ayo manwayo yose yuzuye mwo imbaraga, mu nda y'Isi, twari gukonja cyane muri iveri.

Byakabaye byiza iyaba nashoboraga kubona izo atome zose zuzuyemyo imbaraga.



Byaba bihagiye gushyira mw'icupa izihagiye kugirango nzishyushye muri iveri yose !

Ikitonderwa, Anselimi, za rosoru z'IMBARAGA NYANIKELEYERI zirakomeye cyane kurusha izi IMBARAGA NYASHIMI. ZIKOMEYE CYANE INSHURO AMAGANA Y'IBIHUMBI KUZIRUSHA.



NUWAYO

Amajyini yoherejwe na za nuwayo nyabukana asohokana rero amahane menshi. .

Reka turebe gato niba icyo bwana Aluberiti avuga ari cyo. Amafungwa y'utwo tubuwate anyerera mu buryo bwongerekana. Rero yifungura imwe ku yindi.



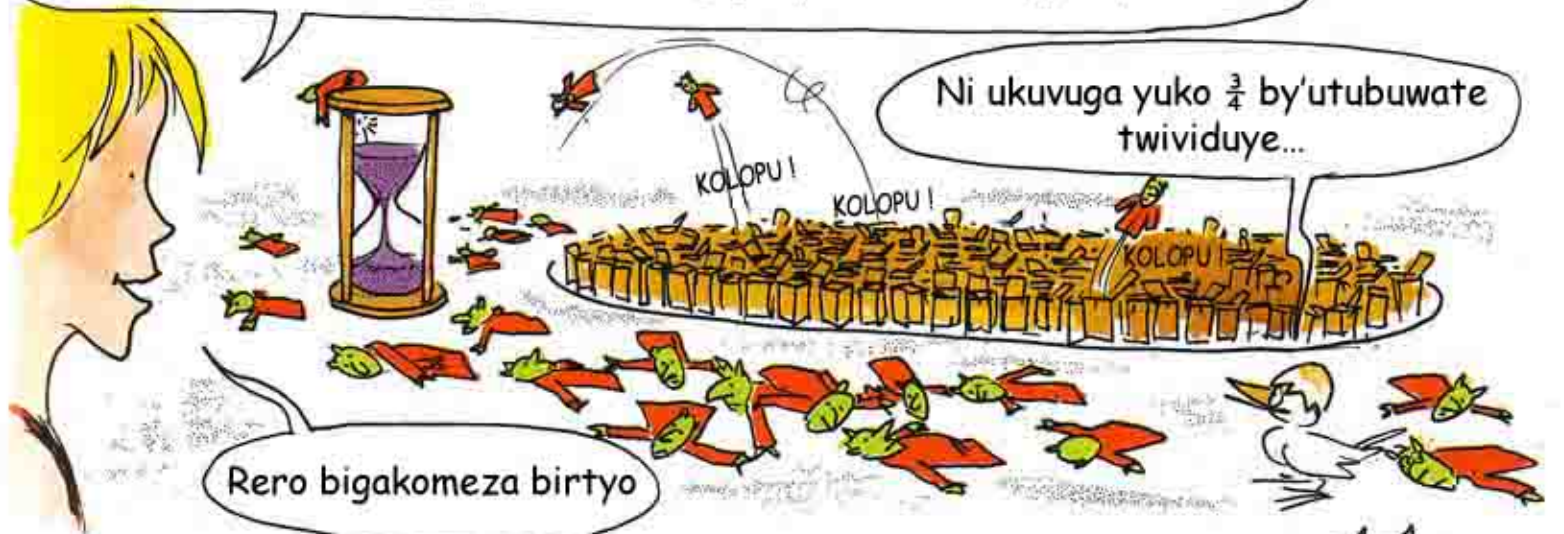
Ndashyira ayo mabuwate amwe iruhande y'ayandi.

Byiza, nyuma y'igihe cy'icyakabiri-buzima, icyakabiri cy'utubuwate kizaba cyavidutse.



Bwana Aluberiti yarafite ukuri.

Nyuma y'igihe cya kabiri, kingana n'icya mbere, kimwe cya kabiri cy'utubuwate twasigaye natwo twajugunye hanze ama jyini ya two.



Ni ukuvuga yuko $\frac{3}{4}$ by'utubuwate twividuye...

Rero bigakomeza birtyo

Muri macye, bigenda bigabanya umuvuduko uko igihe gihita.
Akarindi ko gufunguka k'utubwate kagenda kagabanuka.

Isi yari inyaradiyobukana
cyane igitangira kubaho.

Hanyuma biza guhosha.

IVUNJWA RY'IMBARAGA

Ariko, muri ibyo byose
UBUSHYUHE buri ahagana he ?

Ese uwashyira
ibyo mu nkono ?

Tugerageze...

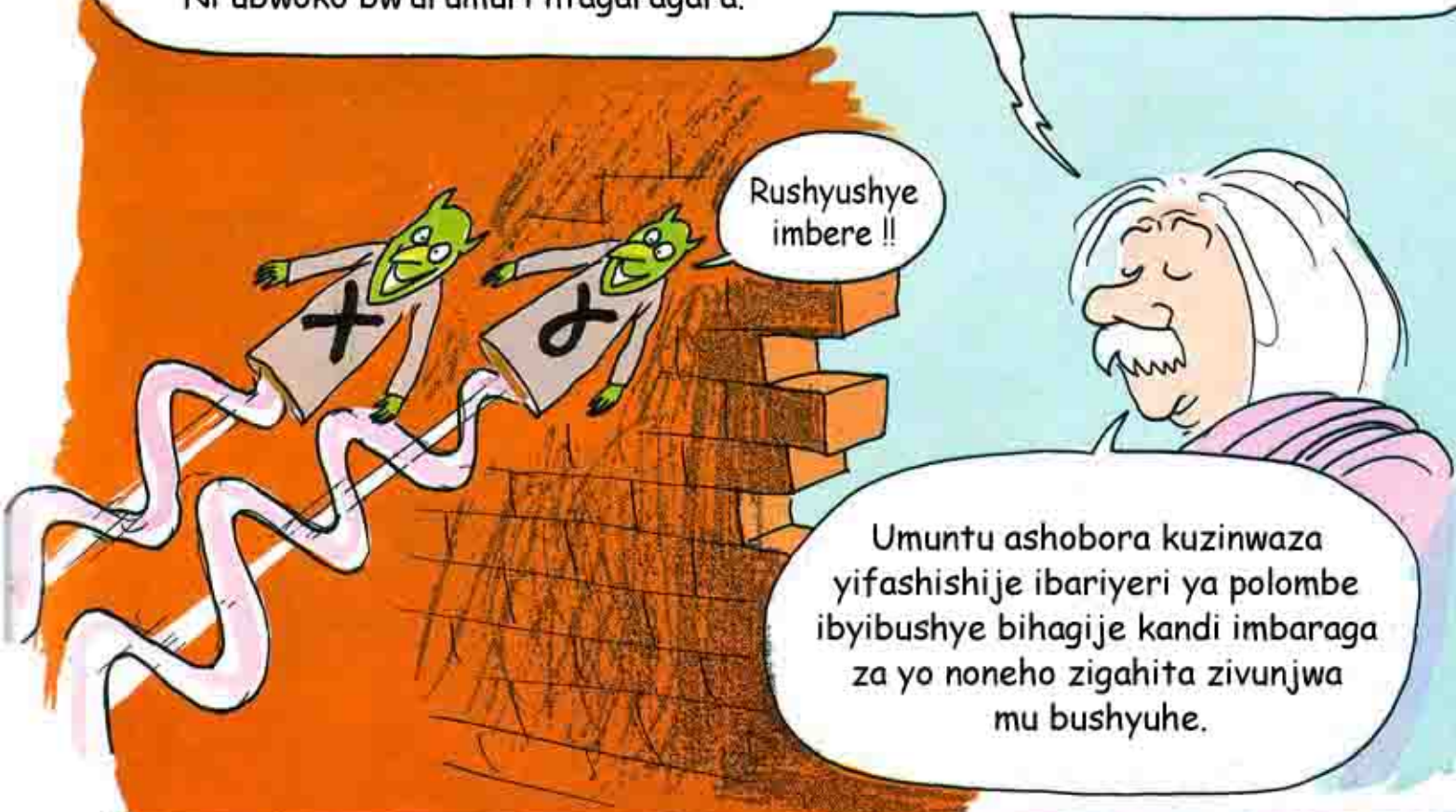
Birakunda ! **IMBARAGA** zoherejwe na z'ATOME NYARADIYOBUKANA
zi jyanwa n'amazi hanyuma **ZIGAHINDURWA MU BUSHYUHE**.

Ariko iyo **RADIYOBUKANA MWIMERERE**
ntirekura **IMBARAGA** nyinshi.

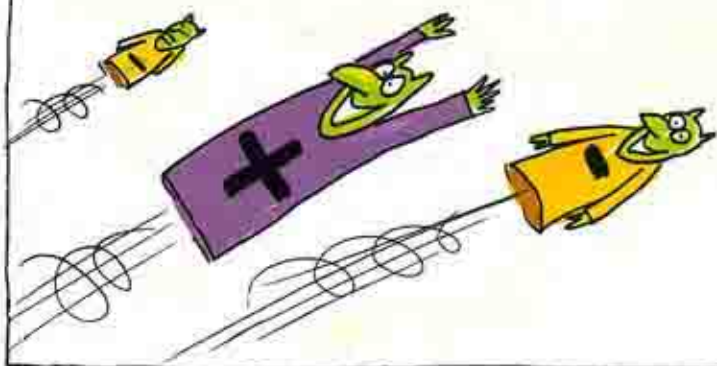
Muri make, hasabwa
ikigero kinini cya matsiyeri
nyaradiyobukana kugirango
umuntu ashobore
kwishyushya.

UBWOKO BUTANDUKANYE BW'UBUJYINI

Mu bigaragara, ntihabaho ubwoko bumwe bw'amajyini. Ikintu cya mbere za nuwayo zishobora kohereza, ni URUMURI X CYANGWA γ . Ni ubwoko bw'urumuri ntagaragara.



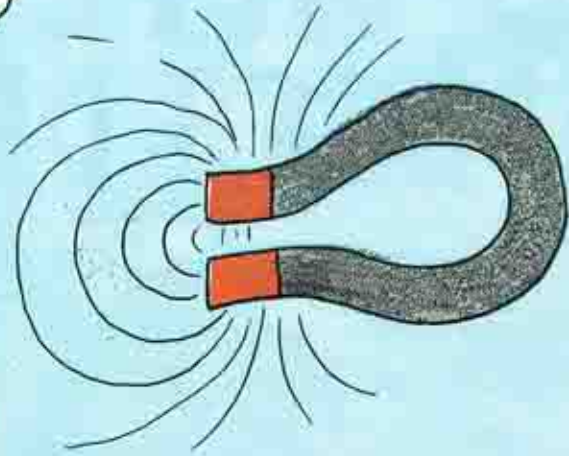
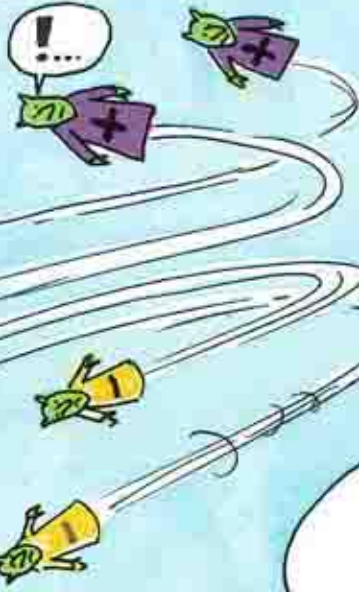
Ubundi bwoko bw'ubujyini ni ubufite UMUZIGO NYAMASHANYARAZI.



Nonese zirihuta ?

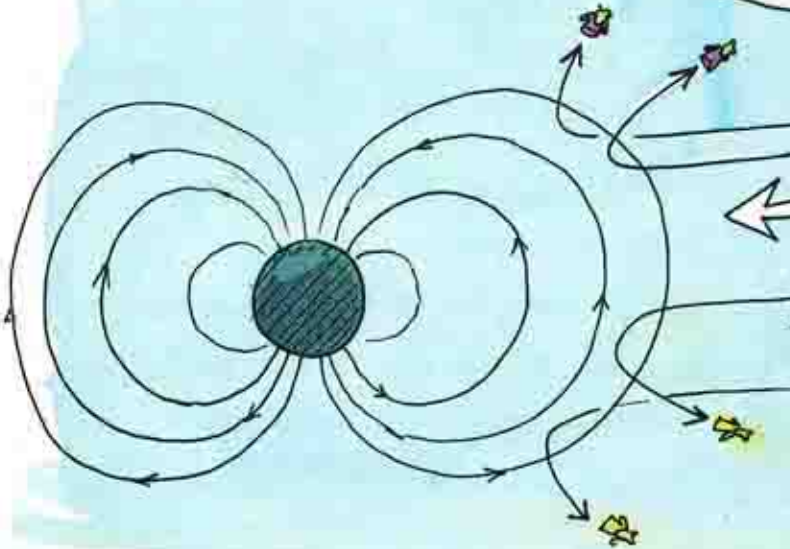
Ibyo biterwa n'IMBARAGA zatwo. Ariko umuvuduko watwo ushobora kugera ku macumi y'ibihumbi by'amakilometero kw'isogonde.

Kuri uwo muvuduko,
tugomba kwambukiranya
icyo aricyo cyose...



Oya, umva ko tudundika
K'UMURIMA NYASUMAKU.

Kimwe n'uko, uduparitikile dusharije
twoherejwe n'izuba (Umuyaga nyazuba)
tudundika ku murima nyasumaku
nyabutaka (*)



Isi rero IKINGIWE
n'umurima nyasumaku wayo.



Ehe yego.
Iyaba isi itari ifite urwo ruzitiro
nyasumaku mwimerere, uduparitikile
dusharije twoherejwe n'izuba twateza
ibibazo bikomeye mu mibiri nyabuzima.

Ubwoko bwa gatatu bw'utujyini nibwo bubi cyane :
ZA NETERONI. Zo nazo zigendera ku mivuduko
ishobora gushyikira km/s 20000. Kuko zitagira
UMUZIGO NYAMASHANYARAZI, ntizishobora
guhagarikwa n'uruzitiro nyasumaku.



Utwo tujyini twose dushobora kugira ibyo
twangiza bidasubirwaho mu mibiri nyabuzima.
Tugomba rero kubyirinda.

Za neteroni na za paritikile nyamuzigo
mashanyarazi bifite mase kandi biba byikoreye
imbaraga rugendo zingana na $\frac{1}{2} mV^2$ zishobora
kunyunyuzwa na solide, n'igitemba, cyangwa
n'umwuka, noneho zigahindurwa mu bushuhe.
Ariko nifuzaga rwose kumenya byinshi
kuri izo nuwayo.



UBUDASHWANYUKA BW'AMA NUWAYO

Kugirango ureme za NUWAYO,
hakenewe za NETERONI, za POROTONI
na ma paritikile yitwa MEZONE.



Za MEZONI muri za NUWAYO, zikora akazi nk'ako
za ELEGITORONI zikora muri za MOLEKILE:
zibumbatira UBUMATANE.

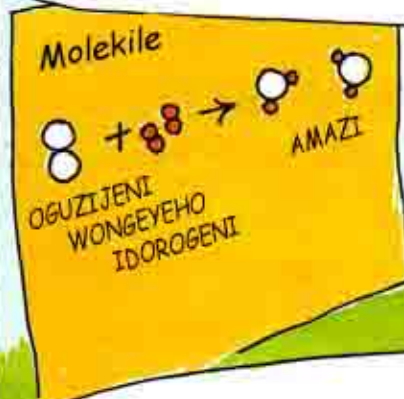
Birtyo rero, za NUWAYO
ni ama MOLEKILE ?



Za NUWAYO ni ama
huzwa ya za NIKELEWONI.
Za MOLEKILE ni ama huzwa
ya za NUWAYO. Kandi,
natwe ubwacu, turi amahuzwa
ya za molekile.



SHIMI isobanura amashyirahamwe
ya za MOLEKILE



FIZIKYE NYANIKELEYERI iziga
amaSHYIRAHAMWE ya za NUWAYO.

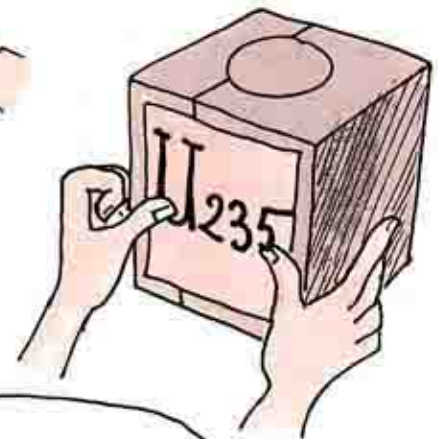
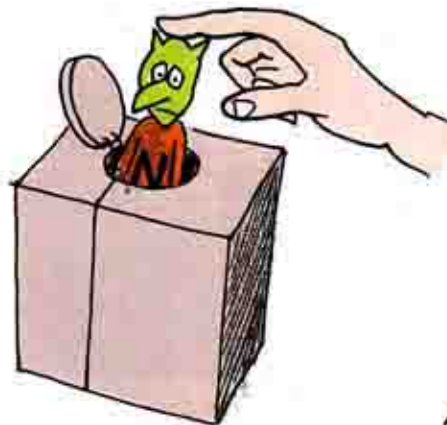
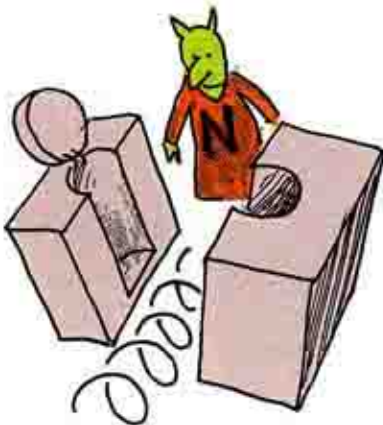
Nuwayo ifatwa nka MBURABURAMBE ni nuwayo ifite igihe cy'ubuzima kigufi.

Ariko za neteroni, zikora impinduka ku manwayo amwe (nayo ngiraburambe mu rugero, kuko afite uburambe bw'ubuzima burebure) zishobora kuzihungabanya cyane rwose hanyuma zigatera ishwanyuka rya zo, IKATIKA rya zo.

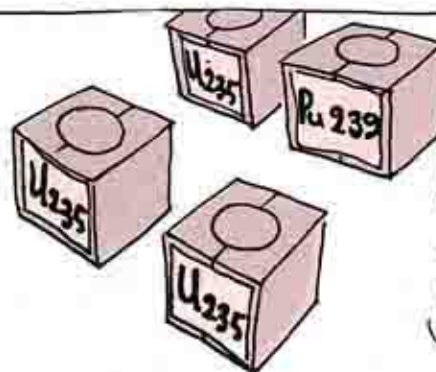
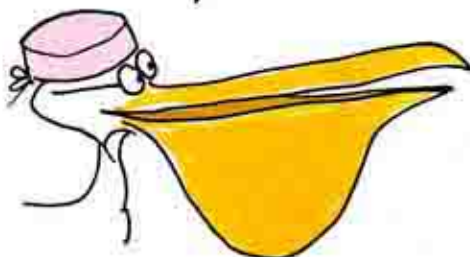
Ni cyo kiba kuri IRANIYOMU 235 na PULITONIYOMU 239.

IKATIKA

Izi nuwayo zishobora kwerekanwa nk'iteraniro ry'ibibumbe bibiri bya mase zitangana hamwe na neteroni imwe.



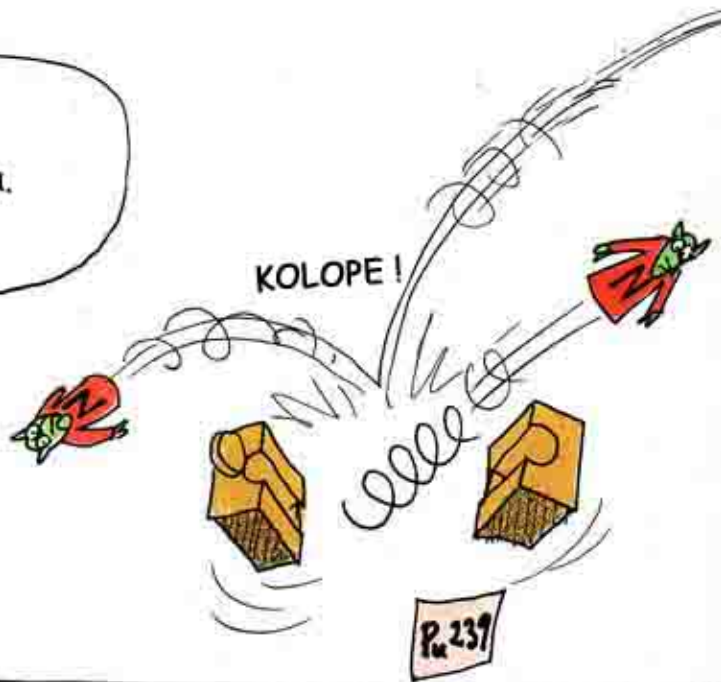
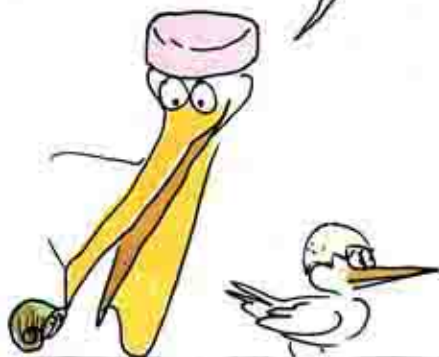
Ama nuwayo ya Iraniyomu 235 na Pulitoniyomu 239 zigaragaza ubwoko bumwe bwa radiyobukana mwimerere, igira igihe cy'ubuzima kirekire cyane.



KOLOPE!



Dore reyagisiyo y'IKATIKA.
Guhura na neteroni byahungabaniye iyo nuwayo ya Pulitoniomu, yahise ishwanyuka. Icyagaragaye nyuma y'iyi reyagisiyo ni iyoherezwa ry'ama neteroni 2 (*).

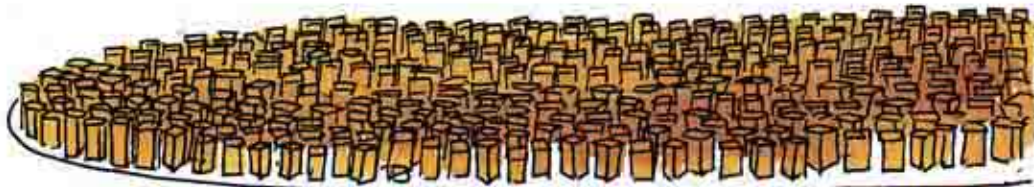


Ngiye kwiga ibyo neza mbyegereye.



Anselimi yegeraniye umubare munini w'utu buwate tw'amajyini hagati muri serikyeri ya reyo R

Iraniyomu 235 cyangwa Pulitoniomu 239



Noneho reba ama jyini MBARAGA asohoka mu tubuwate twayo.



Aha ni za NETERONI.

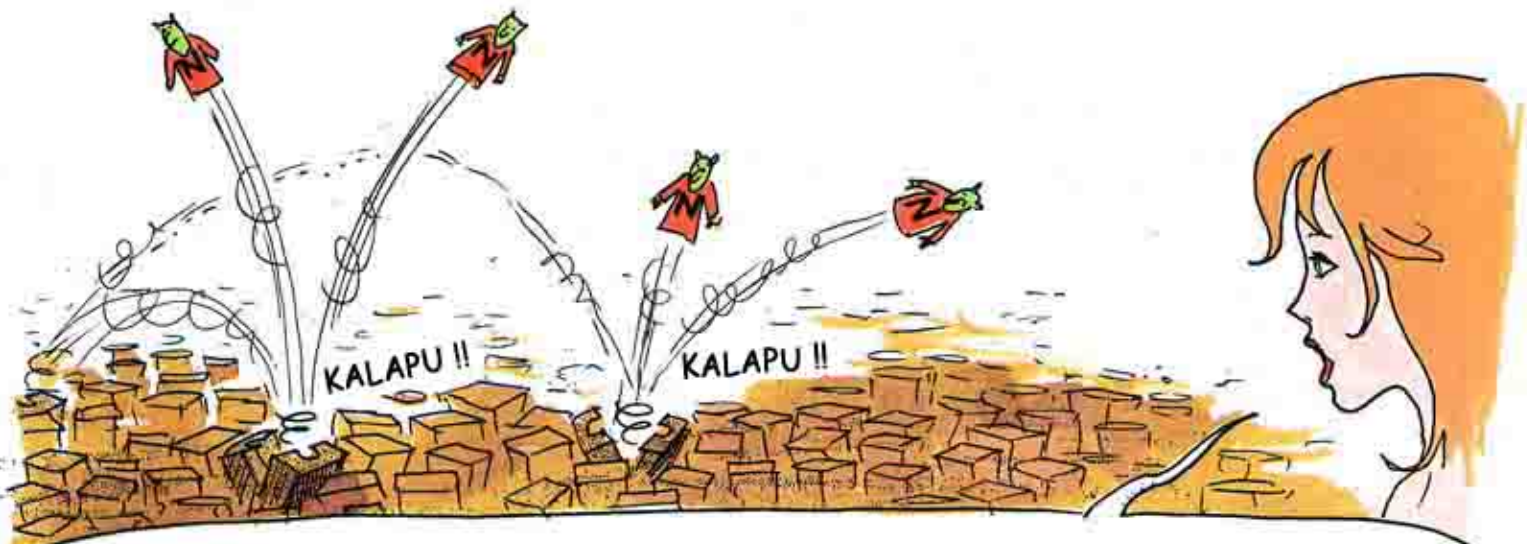
He, urugero ni nk'ibi!



Aka kajyini, mukugonga akabuwate baturanye, katumye igikorwa cyo gushwanyuka cy'ako kabuwate gitangira kandi harekurwa neteroni-jyini yari irimwo.

(*) Iyo shusho ni mfatizo. Mu by'ukuri neteroni ngonzi ubwambere yakirwa na nuwayo nshwanyuka (U235 ihinduka U236 na Pu239 igahinduka Pu240. Ni ayo manuwayo mashya, mburacyicaro bya cyane, yivunagura nk'ako kanya).

REYAGISIYO Z'URUKURIKIRANE



Utu tujyini natwo dutangiza ifunguka ry'utundi tubuwate tubiri !



Natwo, tugezweho, tukongera...



Sofiya, tuve hano...

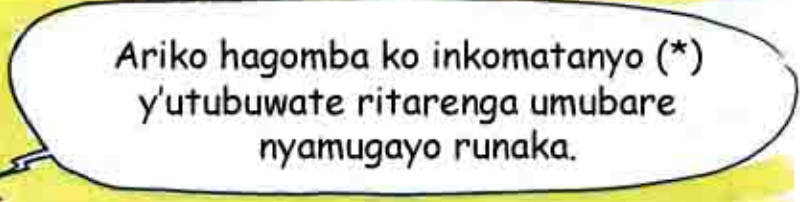
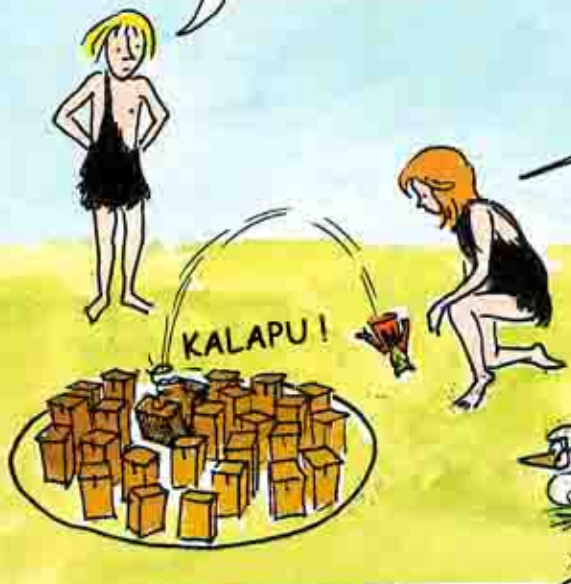
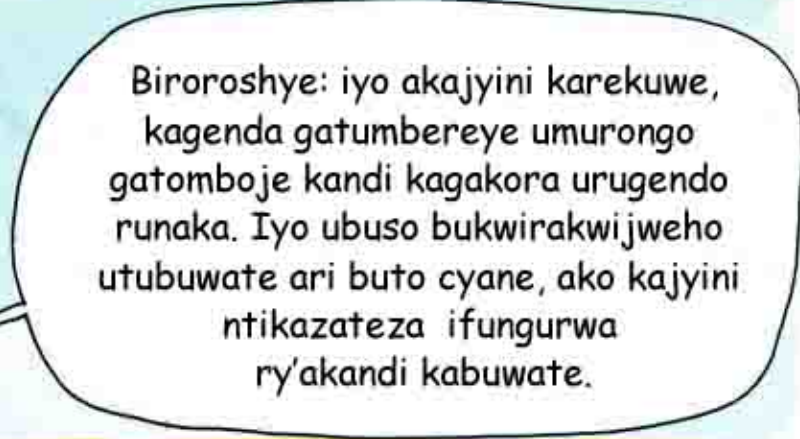


Bowuu, bite se ra !

Iyo amabuwate azakuba ari ama atome nyayo, **IMBARAGA** zose zari kuba zarekuwe muri iyo **REYAGISIYO MUSHUMI** mu gihe k'ikimanyu k'isogonde.



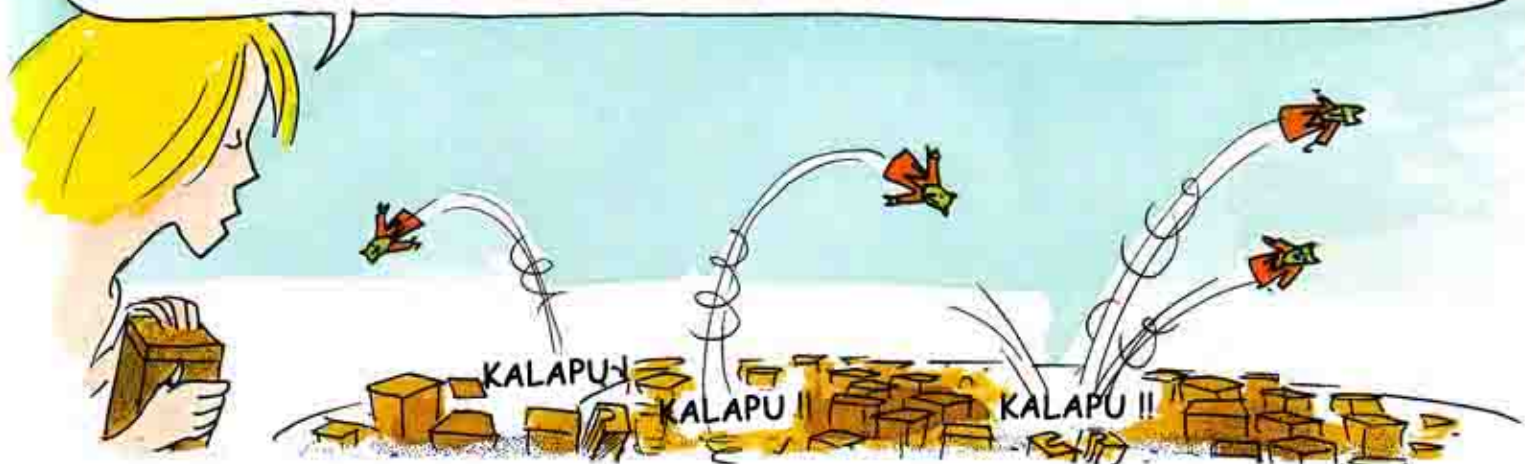
IBISABWA NYAMUGAYO



Hejuru yawo, REYAGISIYO MUSHUMI iratangira.

(*) Icyo gihe havugwa mu buryo bworoshye MASE NYAMUGAYO.

Mu by'ukuri, hagati y'iyoherezwa ryoroheje rya **RADIYOBUKANA MWIMERERE** na **REYAGISIYO MUSHUMI**, hashobora kuboneka umubare wo hagati na hagati. Hibanzwe ku kwiga neza ikoresha ry'iryo **KOMATANIRO**, naho kurigera nyabyo bisaba ubwitonzi bwinshi, hashoborwa gupimanywa umubare runaka w'amajyini arekurwa buri segonde, ni ukuvuga ihita ry'imbaraga zirekuwe.




REYAGITERI NYANIKELEYERI

Ntihakuboneka uburyo bw'akarusho bwo gukurikirana icyo gikorwangiye ?

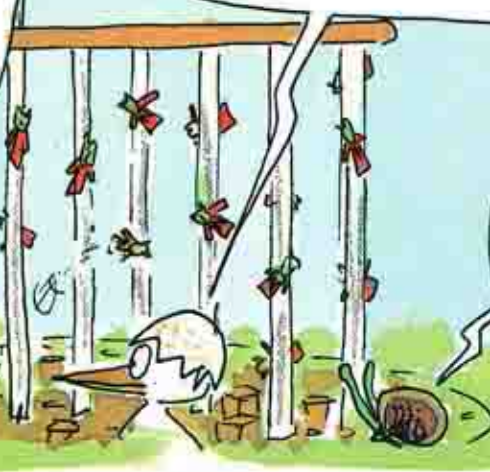
Hakwinjizwamwo ikintu gikacira ayo majyini, izo mbaraga.

Wakigereranya nk'urupapuro nyicamibu.

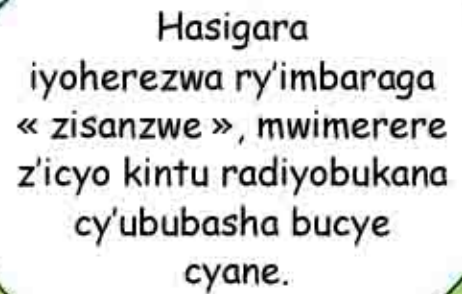




Umanuye cyane birushijeho za bande bujeni zawe ugera naho uhagarika rwose reyagiteri yawe.




Utujyini tyose turakacirwa uko igikorwa ngiro kigenda kiba. Reyagisiyo mushumi zikageraho zigahagarara rwose.




Hasigara iyoherezwa ry'imbaraga « zisanzwe », mwimerere z'icyo kintu radiyobukana cy'ububasha bucyane.


Byiza. Kugirango ukore **REYAGITERI NIKEREYERI**, hagomba kwegeranywa bihagije izo nuwayo ziremereye, **IRANIYOMU 235** cyangwa **PULITONIYOMU 239**. Hanyuma hakazacungwa imikorere ya reyagiteri hifashishijwe ikintu kinwaza utujyini, tuba, muri icyo gihe, ari za netirino z'**IKATIKA**.




Mu bigaragara, ubutare bwa Iraniyomu burimwo 0,7 % ya Iraniyomu 235 (**NKATIKA**). Ibisigaye, ni Iraniyomu 238, itari yo.



Kandi tuzakoresha **KADIMIYOMU** mu kunwaza za **NETERONI**.



Ubanza Pulitoniyomu 239 itabaho hanze aha. Bityo rero twateganya gute kuyikoresha muri reyagiteri ?

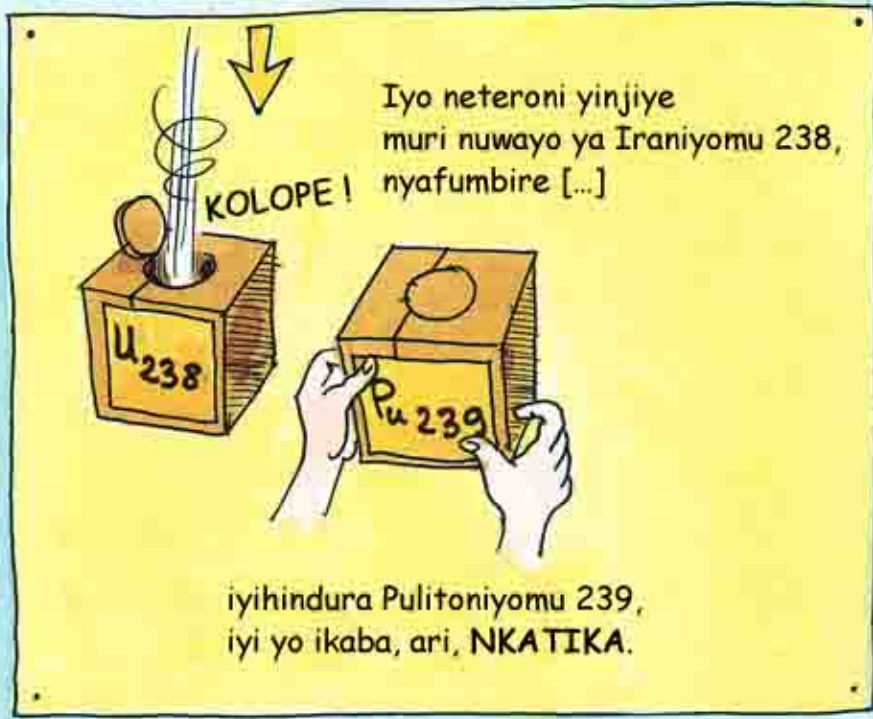


Ehee... yego, ufite ukuri...

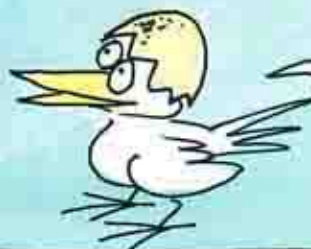
IGIKORESHO NYAFUMBIRE



Iraniyomu 238 ishobora gufatwa, nayo ubwayo, nk' ikomatanyo ry'ibintu bibiri. Hasigaye umwanya wa neteroni

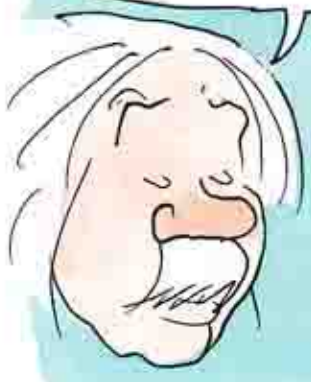


Mu yandi magambo, iyo reyagiteri ya Iraniyomu ikorara, iba irimwo igikoresho NKATIKA hamwe n'igikoresho NYAFUMBIRE. Hakorwa rero, haherewe kuri icyo gikoresho NYAFUMBIRE, ubungane runaka bwa matsiyeri NKATIKA.



Ubungane runaka busobanuye iki ?

Byose biterwa n'uburyo bwifashishwa mugukoresha reyagiteri. Mu ntangiriro, za NETERONI Z'IKATIKA zoherezwa, mu ntubero zose, k'umuvuduko wa kilometero 20 000 kw'isogonda.



REYAGITERI ZA NETIRINO ZIBANGUKA

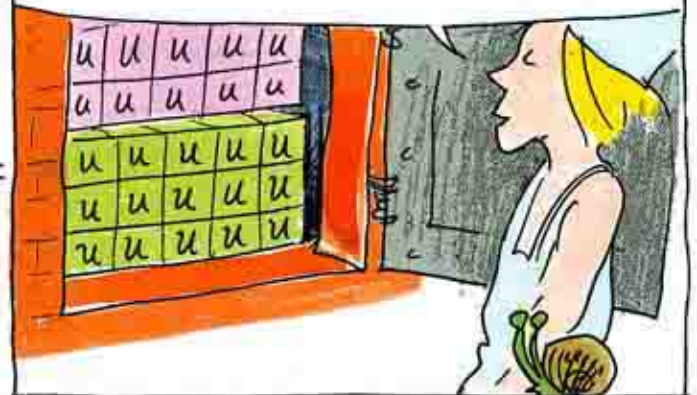
Izo NETERINO ZIBANGUKA zisobekeranya ibikorwa neza na U238, nyafumbire, zikarema Pu239, nkatika, k'umuvuduko ushimishije.

Uriho urakora iki ?



Ndiho ndashira muri reyagiteri yanjye ubutare bukungahaye muri Iraniyomu 235 (Iraniyomu yakungahajwe)

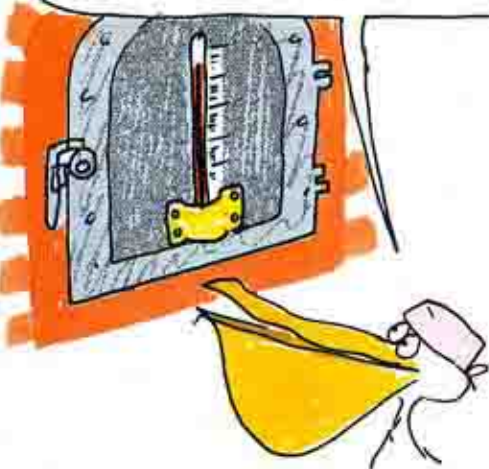
Hanyuma nkagira uMUPFUNDIKIZO NYAFUMBIRE wa U238



Za NETERONI ZIBANGUKA zigendera k'umuvuduko wa km 20 000 /s mu MUTIMA wa REYAGITERI. Ubaye uzigereranije na za molekile za gase, iyi yaba iri k'ubushyuhe bwa dogere miliyaridi 16.

IMYAKA ITATU NYUMA YAHU

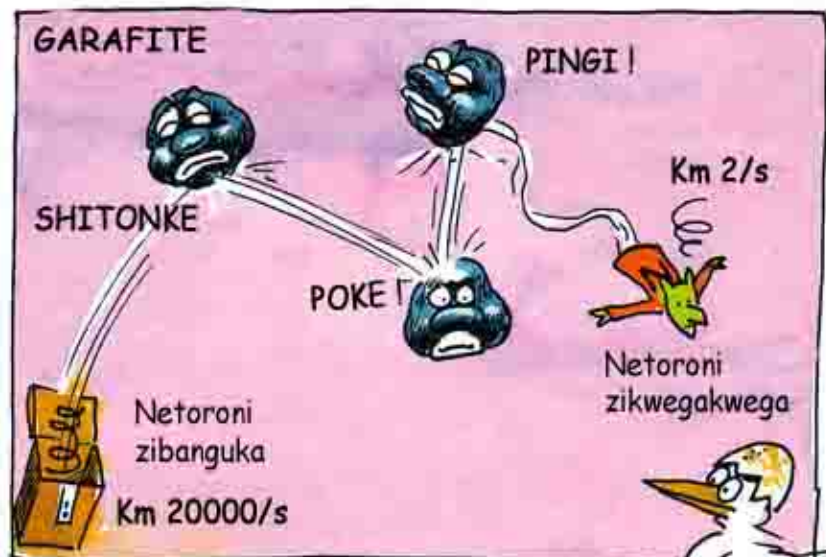
Ohu ! Anselimi yakoze Pu239 nkatika NYINSHI kuruta U235 yakoresheje. Ni SUPERIJENERATERI



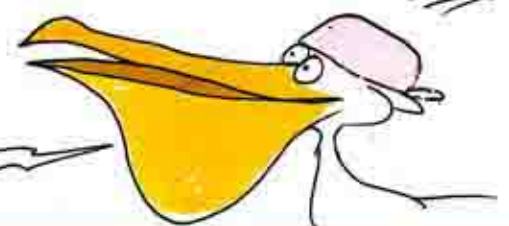
Ni ibyumvikana, kuko buri katika risubiza neteroni zibanguka EBYIRI muri uwo mukino, zigatuma U238 ihinduka Pu239.

REYAGITERI ZA NETIRINO ZIKWEGAKWEGA

Nkoresheje **KADIMIYUMU** nshobora kumira neteroni noneho birtyo ngashyira ku gipimo cy'ibikorwa reyagiteri (cyangwa nkayihagarika rwose). Ariko nkoresheje **GARAFITE** cyangwa **AMAZI AREMEREYE** nshobora **KUGABANYA UMUVUDUKO** wa za neterino ntazimize. Ibyo byitwa **IBYOROSHYA**.



Birtyo ushobora kumanura **UMUVUDUKO W'ITINGISA NYABUSHYUHE** wa za neterino kugeza kuri **Km 2/s**. Uwo mwuka wa za neterino, zikonje, uba uri k'ubushyuhe rusange bw'iyoy reyagiteri.

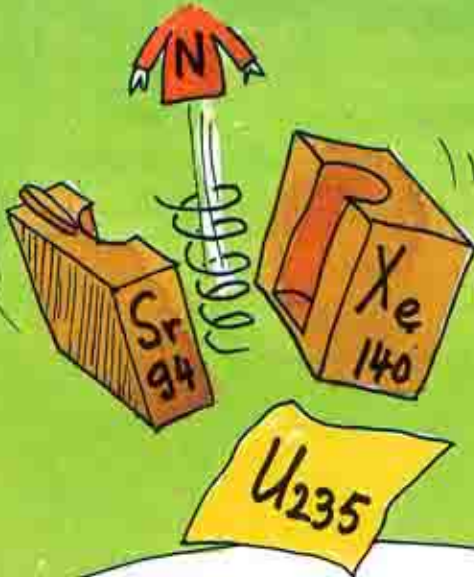


Hakorwa buri gihe **Pu239** nkye, ariko nkye cyane ugereraniye n'iyoy muri reyagiteri ya neterino zibanguka.

Nta rubibe rugaragara hagati y'ubwo bwoko bubiri bwa za reyagiteri. Habaho kandi rwose za reyagiteri za neterino « kazuyazi », ziri hagati na hagati ya zazindi ebyiri.

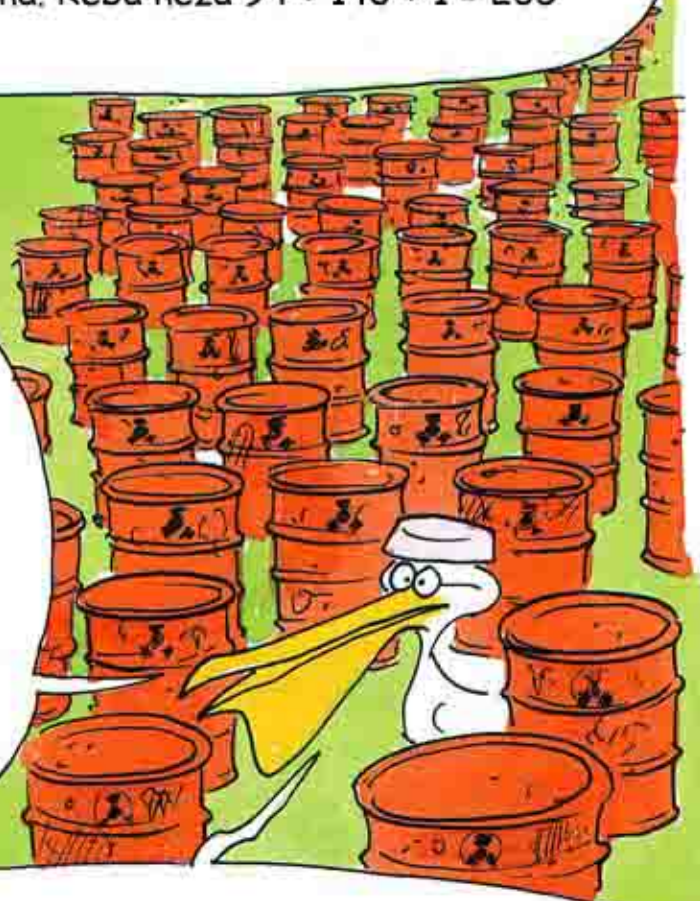


IMYANDA NYARADIYONKORA RADIYOMIKORO NTURUKAMWO

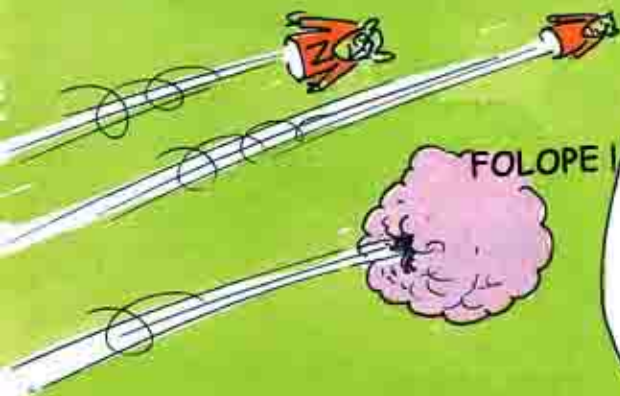


Za nuwayo za U235 n'iza Pu239 zishobora kwikatamwo kabiri mu buryo bwinshi bunyuranye. Aha urugero ni Iraniyomu 235 yikatamwo kabiri igatanga Sitoronsiyomu 94 na Zenoni 140 radiyobukana. Reba neza $94 + 140 + 1 = 235$

Ibyo byose birarushya. Byinshi muri ibyo **BIKORESHO BY'IKATIKA** bifite ubuzima buruhaniye kandi bikomeza kuba radiyobukana mu gihe kirekire cyane. **SITORONSIYOMU** yitekera mu magufa naho **IYODE** mu ngoto. Pulitoniyoumu nayo ni nyonyonyi cyane. Ibyo byose bitera za **KANSERI** na za **LESEMI**.



Za neteroni z'ikatika zishobora kumirwa na za atome zituje, zigize imiterere ya reyagiteri, zigahita zihinduramwo za nyonyonyi mburaburambe, zaradiyobukana nazo kandi, zizajya kugwiza mase y'imyanda.



RADIYOTUGINGO KU GIPIMO



Reyagiteri itanga rero imyanda mburaburambe, radiyobukana, y'ibihe cy'ubuzima binyuranye.

Oya. Ni amanuwayo ashobora gutakaza uburemere igihe ajugunya amanuwayo ya heliyomu, za elegitoroni cyangwa za ndwanya-elegitoroni (*)

Urashaka kuvugako ari za nuwayo zishobora nazo kwikatamwo ibice ?

Nguko, dore Anselimi utwaye imyanda.

KALAPU!

Nshobora gukora za radiyotugingo dufite ibihe binyuranye, za nuwayo za radiyobukana « zo ku gipimo », ushira utugingo tumwe muri reyagiteri noneho tukamishwa urufaya rw'utugini. Birtyo rero tuzabona ntangaradiyobukana yitwa NKORANO.

Ndi umushakashatsi mukene w'ingunjye

KALAPU!

Galiyumu 68. IGIHE : ISAHA 1

(*) Inyabukana "alufa" cyangwa "beta".

Za **RADIYOTUNGINGO NKORANO** zavumbuwe mu myaka ya 1930 na **FEREDERIKO NA IRENE JOLIYO-KIRI**, ibyo byayoboye, imyaka mikye nyuma yaho, kw'ivumburwa ry'**IKATIKA**.

Ohu, reba! Anselimi yaburiwe irengero, ariko dushobora **KUMENYA AHO ARI** biturutse k'utujyini dusakazwa n'umuzigo we.



KALAPU!

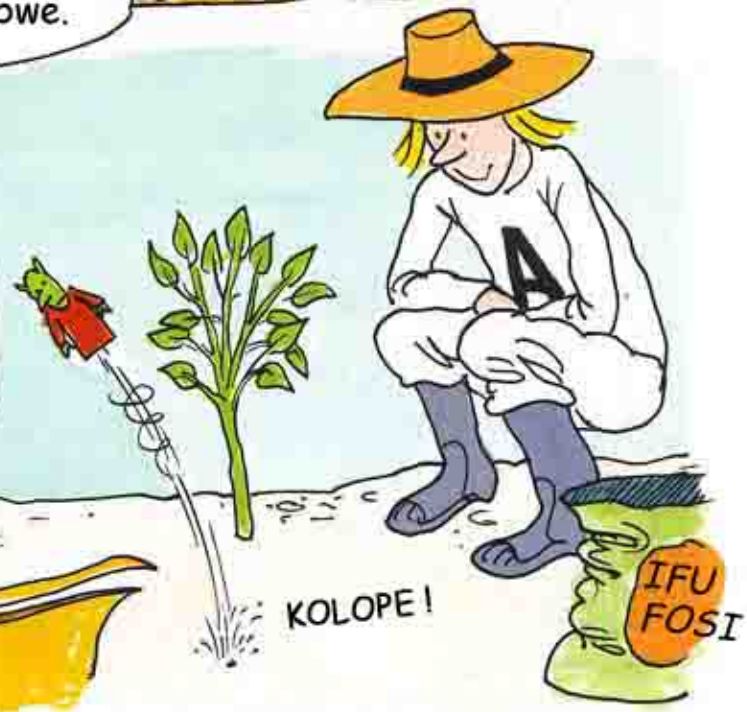
Mfite igitekerezo! uvumbuye iryo yoherezwa rya za paritikile, ukoresheje **NTANGARADIYOBUKANA NKORANO**, ushobora gukurikirana za nuwayo **AHO ZICA**.

Unashobora no gushyira ibimenyetso kuri za nuwayo, za izotopu radiyobukana, kuri za molekile nyabuzima (**ISHYIRAKIMENYETSO**). Bizatuma bishoboka ko hakurikiranwa isuhuka ryayo mu ngingo nyabuzima.

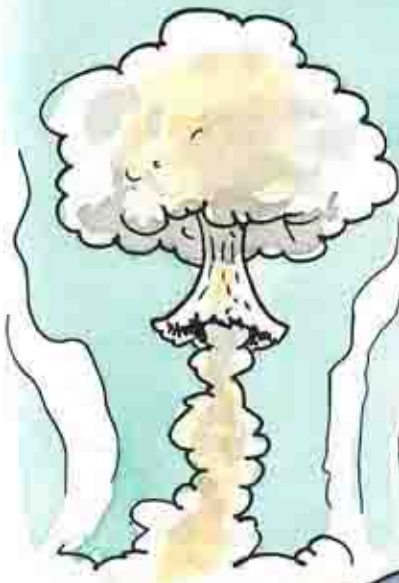


He, hari umugiziwanabi mburaburambe muri twebwe.

Hariho ibihumbagiza by'amashyirwamubikorwa nzanamahoro ya ntangaradiyobukana nkorano. Akarorero hashorwa kwigwa isuhuka ry'amafumbire mu butaka, hashyizwemwo muri za fosifate izotopu radiyobukana ya fosiforo.



ZA BOMBE A



Fizikye Nikereyeri yatumye ubumenyi bw'imiriro ryenge itera imbere bitangaje. Uhubutse ugateranya mase ebyiri z'ibikoresho nkatika (U235 cyangwa Pu239) wifashishije igisasu, urema Imbibemikorere neguzi hanyuma ugatangiza reyagisiyo mushumi nini, hamwe n'ingiro zigaragaza uburanga budashidikanwa.

Turebe. Nteranije ayo ma mase abiri, mbona **MASE NEGUZI.**

Umubare munini w'utujiyini tw'ubwoko bwose turasakazwa noneho imyanda radiyobukana ikajyanwa muri atimosiferi hejuru mu muzamuko uterwa n'irekurwa rinini ry'ubushuhe. Bigatuma tunahaho abaturanyi.



Nimba mushaka kwinjira mu gikundi cya **BARYENGE MINEZERO**, muzagomba kuba mufite ibikoresho nkatika nyabyo (100% bya U235 cyangwa bya Pu239). Mufite ibisubizo bibiri : hari kuryoshya Iraniyomu mwimerere, cyangwa kugana kuri reyagiteri iri bugufi y'aho utuye, ukayora Pu239 yakozwe nyuma ya buri muzenguruko nyabikorwa.

Biraje, biraje !..



iHUZO



Umva rero, izuba, ni palaneti igomba kuba irimwo Iraniyomu nyinshi, niyo mpamvu ishyushye cyane se ?

Oya, Anselimi, ntabwo ari gutyo. Muri za **REYAGISIYO NYASHIMI**, dutangirira ku imvange y'ibintu, urugero nka **IDOROJENI** na **OGUZIJENI**.

Ariko... ntakiba... na gito ?!

Ni ukuberako ubushyuhe butari hejuru bihagije.

Dushyushye iyo mvanjye

PAFU!

Noneho se bitanga iki ?

H₂O, amazi

Rero, hariho za reyagisiyo zirekura imbaraga nyinshi zidasohora ibintu bihumanya.

Nihabaho igihe tuzakoresha indege zigurukishwa n'imvange ya idorojeni na oguzijeni (bihunitse mu miterere nyabuzi) zizasiga gusa aho ziciye... ibicu !

Yenda no « gutwika »
invange y'amanuwayo birashoboka.

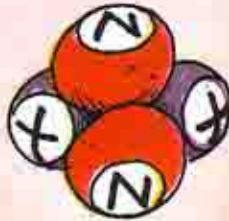
Ukazirikana kuzicanira
ku gipimobushyuhe kirekire
bihagiye.

Ushobora kubyaza
ibishya **DETERIYOMU** na
TIRITIYOMU, byo ni ubwoko
bubiri bwa **IDOROJENI**
IREMEREYE (nuwayo ya
idorojeni yoroshye igizwe na
porotoni P imwe rukumbi).
Nuwayo z'izo **IZOTOPU**
zitandukanijwe n'umubare
wazo wa za netoroni.
Imvanjye Deteriyomu-
Tiritiyomu yihutira gutanga
Heliyomu.

DETERIYOMU

TIRITIYOMU

HELIYOMU



iHURIRO Rinini
NYAMAJYini

Dore akagingo ka gaze ya
IDOROJENI IREMEREYE,
kimwe cya kabiri cya **DETERIYOMU**,
kimwe cya kabiri cya **TIRITIYOMU**.
Ku gipimo cy'ubushyuhe gisanzwe,
za **ELEGITORONI** zizenguruka
iruhande ya za nuwayo kandi zikaba
ibiraro nyamolekile (zihuza za
nuwayo ebyirebyiri).



Molekile ya Deteriyomu



Molekile ya Tiritiyomu

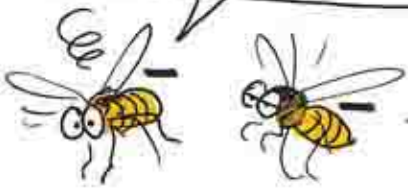
Hanyuma umurindi w'igitaramo uhinduka by'ukuri nnyamajyini. Za molekile zirashwanyagurika (itandukana) noneho za elegitoroni-nyuki zizenguruka iruhande ya nuwayo imwe rukumbi.



**KUGANA KURI DOGERE
IBIHUMBI BITATU :**

Ntaburyo bwo kuzenguruka iruhande y'ayo ma nuwayo, aragenda buri kanya.

Pufuuu...



Yego, byabaye isibaniro. Jyewe ndabihebye...

Gaze ishyushye ihinduka isupu y'ama nuwayo n'ama elegitoroni yibunza, i **GIKOMA GISHYUSHYE.**



Shyushya, Mariseli, shyushya !

Muzi ibindi ?
byaruta tubaye bane

Kuva kuri **DOGERI MILIYONI 150 (IGIPIMO CY'UBUSHYUHE CYO KUGURUMANIRAHU)** havuka ikindi kintu

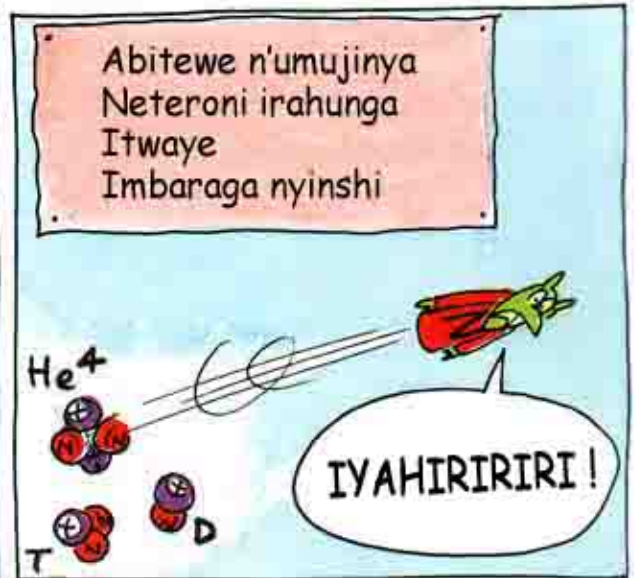
Ni ko ubibona ?

Zareze...

Ndumva inkota mu mugongo

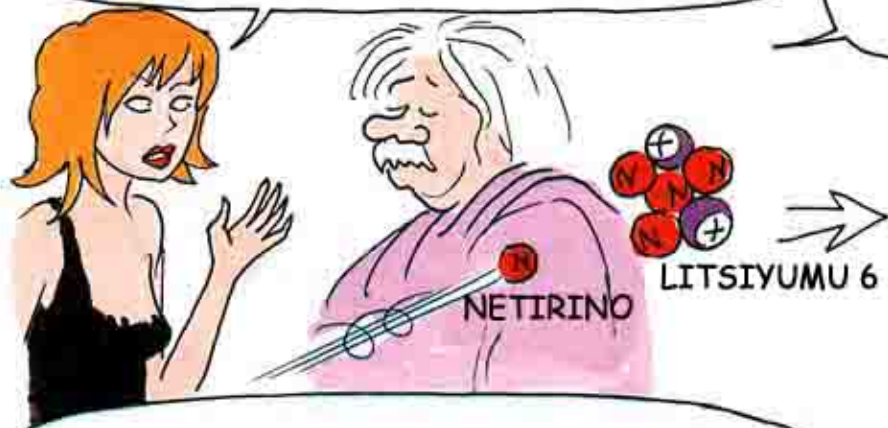
Yego, kuri icyo gipimo cy'ubushyuhe, twaba dufatanye kurushaho

He, mube muretse !
 $2+3 = 5$, kandi Heliyomu ifite nikelewoni 4, si byo ?



Rero, iHUZO naryo ryangiza ibidukikije nk'iKATIKA, kuko izo netoroni z'ihuzo zijya guhindura ama atome maturanyi, ziyahinduramwo ama atome radiyobukana.

Ariko twihutira kumira izo netoroni hifashishijwe litsiyumu 6, izatanga eliyomu 4 na tiritiyumu 3



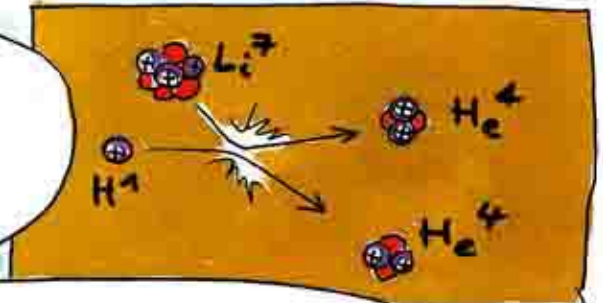
Mu yandi magambo, ibahasha ya Litsiyumu 6 yigenza nk'igikoresho « nyafumbire ». Iyo reyagisiyo isanzwe izwiho gutanga « ibitwikwa by'ihuzwa », tiritiyumu 3.

Yego, reyagiteri y'ihuzo ifite isano na ndengerajenerateri. Kandi ni amahirwe, kuko Tiritiyumu, mburaburambe (*), ntibaho mu bihe bisanzwe.



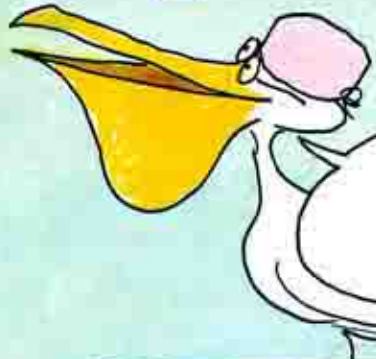
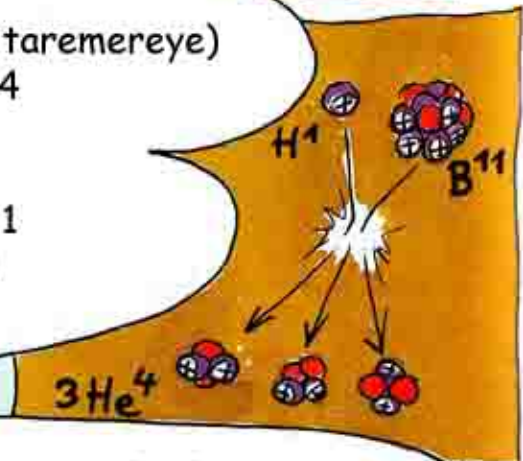
(*) Cyakabiri-buzima cya yo cyingana n'imyaka 12.

Ariko kandi, ndabona ko habaho amatsinda ya za reyagisiyo z'ihuzo, z'imihindurire ya za nuwayo bidatanga netoroni zibunza.



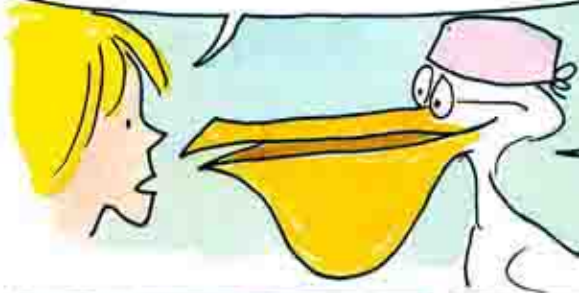
Litsiyomu 7 + Idorojene 1 (itaremereye) bitanga 2 Eliyomu 4
 $(7+1 = 2 \times 4)$

Bore 11 + Idorojene 1 bitanga 3 Eliyomu 4
 $(11+1 = 3 \times 4)$



Iyambere igira igipimo cy'ubushyuhe cyo kugurumaniraho cya dogere miliyoni 500. Naho, kuya kabili, bikorakora dogere miliyaridi !

Humu... mu by'ukuri... Mu buryo bufatika, duhuza duta za nuwayo ?



Mu nda y'Izuba, ibyo byikora buhoro buhoro, ku gipimo cy'ubushyuhe kinga gusa na dogere miliyoni 15



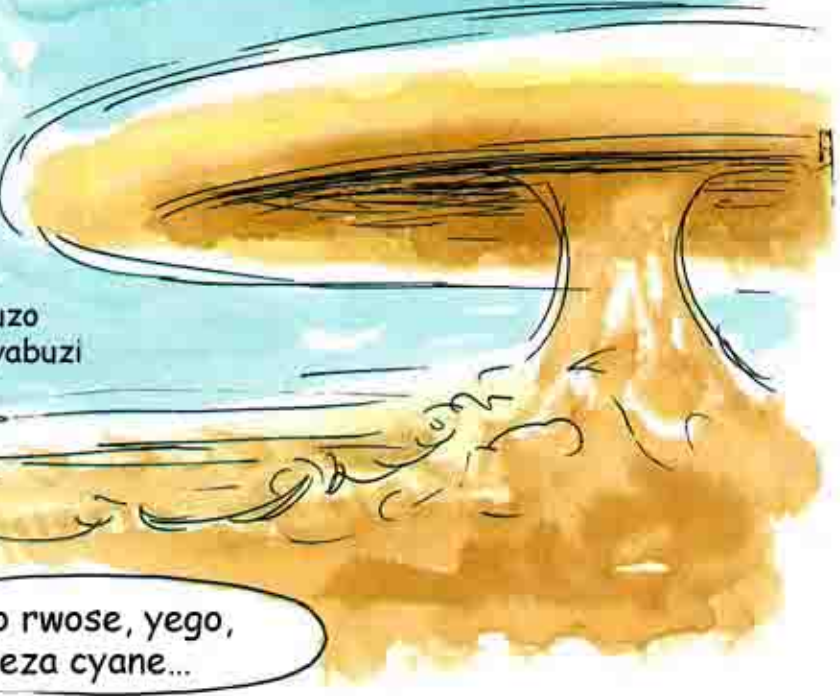
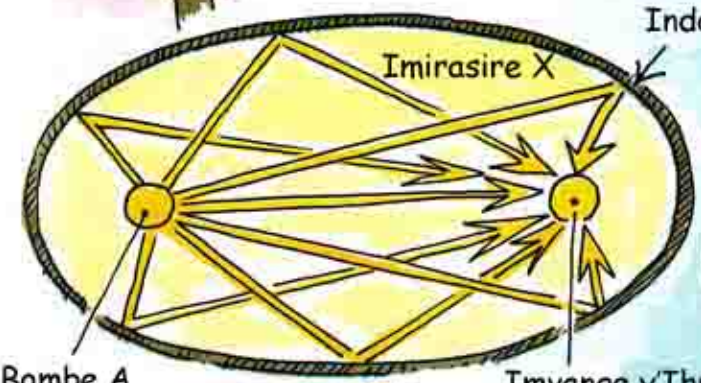
Izuba ni nk'ikara, ni byo ?



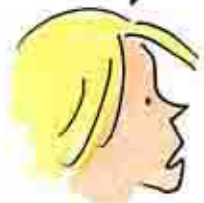
Yego. Kugirango ubone « umuriro » nyanikereyeyi, hakenewe dogere miliyoni 150, kugirango za reyagisiyo zikore, tuvuge, mu gihe twabarira ku rwego ry'isogonde.



Humu, Eduwaridi Teller yakoze ihuza avumbura bombe nshya. Ntabwo twashakaga gukora ibyo. Ariko twarabikoze. Teller yagize igitekerezo (*). Yagiraga buri gihe ibitekerezo byiza cyane. Igihe bombe A ituritse, itangira gucira, mu mwanya w'ibice bya mbere bya rimwe kuri miliyoni by'isogonde, ikigero kinini cy'imirasire X. Teller yatanze igitekerezo cyo gucyamura iyo mirasire hifashishijwe ubwoko bw'indorerwamu, noneho ikayoborwa ku ndaswa igizwe n'imvange ya Deteriyomu - Tiritsiyomu.



Nonese byarakunze ?



Byo rwose, yego, neza cyane...

(*) Eduwaridi Teller, umushakashatsi i LOSI ALAMOSI mu gihe k'intambara, yabaye intangarugero ku filime DOGITERI FOLAMURU.

Teller yanubatse indorerwamu
muri Iraniyomu 238

Kuki,
Iraniyomu 238 ?

Yego pe, zicyamuwe. Bombe H iraturika.
Za netoroni z'ihuzo zigatera igikoresho
GIKUNGAHAYE U238 hanyuma
zikagihinduramwo Pu239 ihita
yikatagura ako kanya.

Ni ya bombe karahabutaka
IKATIKA-IHUZO-IKATIKA

IHUZO HAKO RESHEJWE IMBARAGA ZIYOBOWE

Tugerageza gushyira mu bikorwa IHUZO
tuyobora ku mvange **DETERIYOMU-TIRITSIYOMU**
(iri mw'iforoma nyabuzi) ubwoko bwose by'**IMBARAGA**:
imirasire, iturutse kuri za **LAZERI** zikomeye cyane,
uduparitikile tunyuranye: elegitoroni, nuwayo ziturutse
mu manyongeramuvuduko. **INGUFU** zo gukoresha ni
umurengera. Hagomba (mu bice bya rimwe kuri
miliyaridi ya sogonde), kugirango hatswe uwo muriro
BUSHYUHENIKELEYERI, kurundanya ingufu zingana
n'izo indorerwamu nyazuba yaba ifite ubuso bungana
n'ubw'u Bufaransa, kuri siferi ya diyametero
itanafite mm1 !

INGUFU Z'AKO KANYA ni umurengera
ariko **IMBARAGA** zose ntabwo ari nyinshi :
iki « kibiliti » nyanukeleyeri gihwanye
na garama magana abiri za puderi.

IMBANZIRIZAMUSOZO

Dukeneye **IMBARAGA NYANIKELEYERI**.
Ariko ibyo byose, **IKATIKA, IHUZO** bifite
byose ingaruka mbi.

Hari
imyanda mibi !

Hamwe n'umurundo
w'impanuka zishobora kubaho.
Nka reyagiteri iramutse ihiye,
yashongesha inkono ya asiye,
beto, n'ubutaka ubwabwo
**(INYIBUTSAMPANUKA YO
MU BUSHINWA (*)**) hanyuma
mase iri mw'ikatika ikinjira mu
butaka kandi mu buryo
ntawashobora kubihagarika.

Hakorwa iki ?

Imyaka 40, ni mikye.
Turacyari kw'itangiriro ry'**IBIHE
NYANIKEREYERI**.

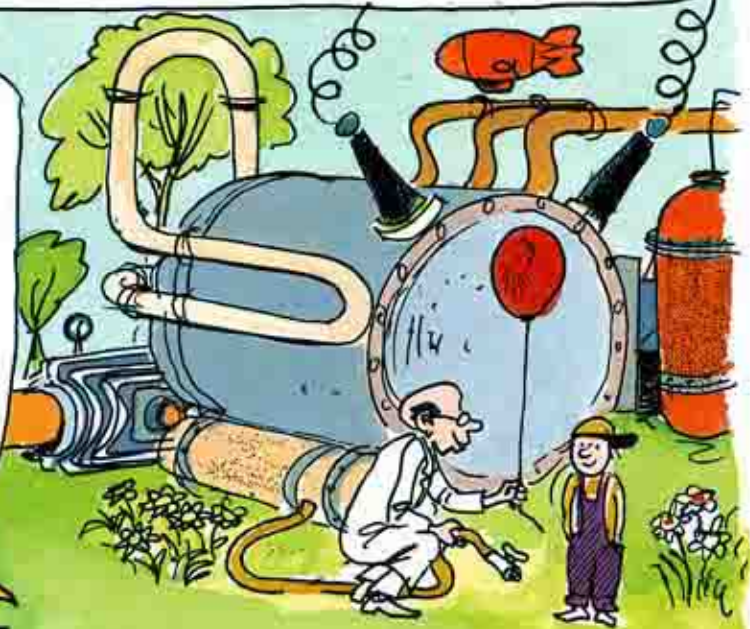
Jyewe, nemerako amajyambere
mpinduramatwara ashoboka, yatuma rwose
hahinduka imiterere y'ikibazo, ariko cyane
cyane k'uruhande rwa **NKOMATANYA**
kuruta urwa **NKATIKA**.

Ahu...

(*) Ishusho yakozwe n'inzobere z'ama atome, hatekerejwe ibya reyagiteri,
yakwambukiranya Isi iva k'umutwe igana k'uwundi, ikazaserukira... mu Bushinwa !..

Muri za reyagisiyo z'ihuzo, aho za netoroni zitazamwo m'uburyo zigenga, birashoboka byibuze mu bitekerezo, **GUFUNGIRA HAMWE** ibyo **BIKOMA BY'IHUZO** hakoreshejwe ibikoresho bikomeye nyasumaku (za paritikile zikoreye amashanyarazi « zihunga » uturere turangwamwo imirima nyasumaku nyambaraga).

IBIHE BY'AMAHIRWE !
ITanure ry'ihuzo, ritangiza ikirere (litsiyomu - idorojene cyangwa bore - idorojene). Insohoka rukumbi muri reyagisiyo : Eliyomu, ishobora kwifashishwa mu guhaga imipira y'abana !



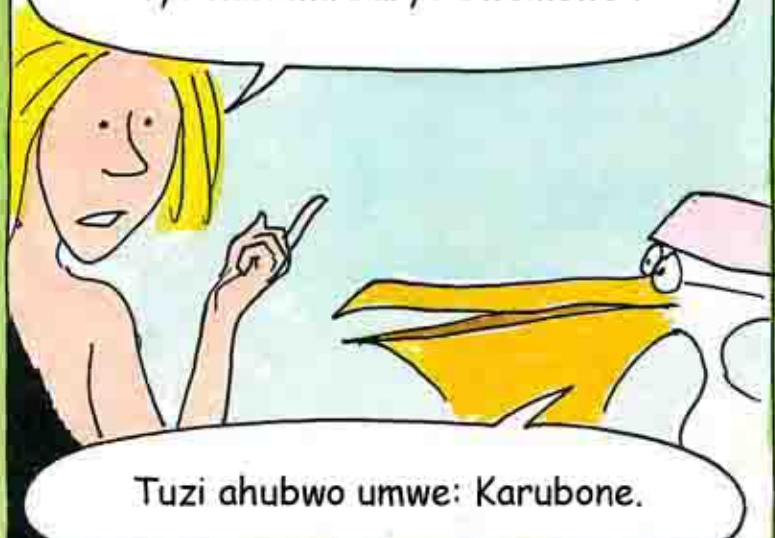
Ndeka nisekere, ni indoto !

Ibiramambo, habaho ama panu y'umusemburo atuma hatswa umuriro **IWUMUNTU**, amadirishya afunze, hatanakoreshejwe iyoboramwotsi !..

Ni ukuri.
Ibyo bitanga vaperi z'amazi na gaze karubonikyeye, byo bishobora guhumekwa, mu kigero cyoroheje.



Ese hashora kubaho **UMUSEMBURO W'IHUZO** watuma hakorerwa ku gipimo cy'ubushyuhe cyo hasi mu buryo bwemewe ?



Tuzi ahubwo umwe: Karubone.

Ehe yego, ahubwo se, Izuba ribyifatamwo rite kugirango rikore ihuzo, kandi inkono nyamukuru ya ryo iri kuri dogere **MILYONI 15**, ni ukuvuga igipimo cy'ubushyuhe **CYO HASI INSHURO CUMI UGERERANIJE N'IGIPIMO CY'UBUSHYUHE CYO KUGURUMANIRAHO**, cyo kiri kuri **DOGERE MILYONI 150** ?

Karubone ikora nk'umusemburo. Yinjira mu nzego, zikomeye bihagije, za reyagisiyo kandi, nyuma ya byose, ikongera ikaremwa. Ibyo bitangirana na Karubone 12 hongewe ho Idorojeni 1 bitanga Azote 13. Hanyuma iyo Azote 13 ihindurwamwo azote 15, noneho ubwanyuma :
Azote 15 + Idorojeni 1 -> Karubone 12 + Eliyomu 4 (inzenguruko ya Bethe)

Ariko iyo reyagisiyo igenda **BUHORO** cyane (uretse kubereke Izuba, kubera ko ryo rifite umwanya waryo wose).

ZA MIWONI

Dushobora kurema, mu mvange y'imyuka ikonje, za reyagisiyo nyashimi zikomeye hamijirwa, ku mamolekile, ama elegitoroni z'umutwaro umwe mashanyarazi.



Urugero :
 2CH_4 (metane)
 + $\frac{1}{2}$ (umutwaro mashanyarazi) bitanga :
 C_2H_2 (asetilene) + 3H_2

Dushobora, muri molekile, gusimbuza za elegitoroni na za **MIYONI**, izi ni paritikile zisa na elegitoroni ariko nini kandi zegeranya za nuwayo zimwe n'izindi.

Ahubwo se, kuki tutamija za Miyoni ku mvange y'Ihuzo « y'akazuyazi ».

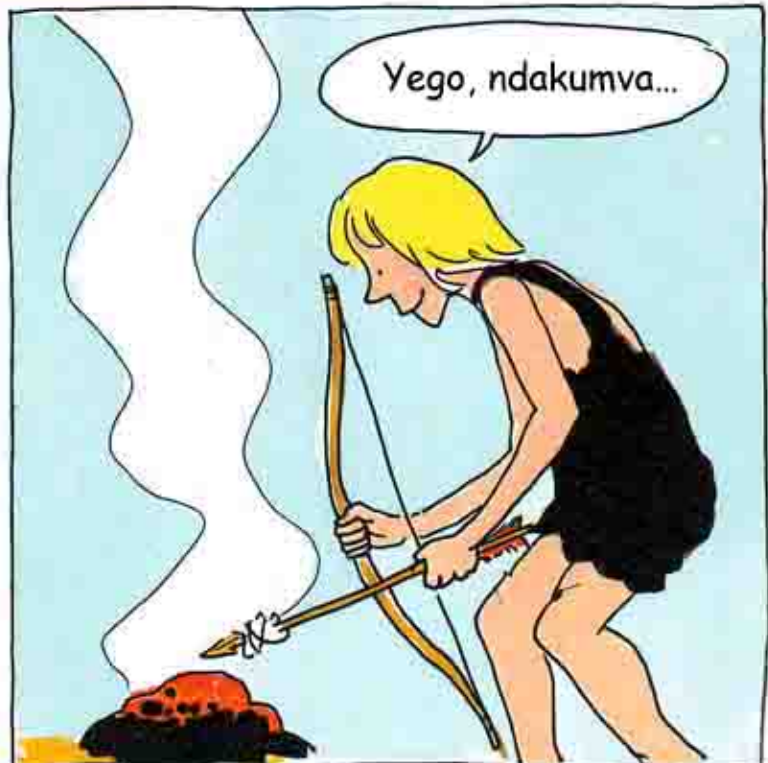
Biragenda ?

NTA KIBAZO, DATABUJA.

Tuzi gukora za miyoni muri agiselerateri.
Igihe zisekuye za nuwayo za deteriyomu n'iza
tiritsiyomu, bibyara Eliyomu. Rero hariho ihuzo.
Ariko, hagati y'aya mageza ya mikorofizikye,
ikoresha amaparitikile makye n'ihuzo nyaruganda
mbyaranyungu, hariho inziro ndende yo kugenda !!!

Dushobora naho kandi gukora amageza kuri za **SIPINI** z'ama nuwayo.
Ni ukuvuga kuzibyinisha valize mu mwanya wa tango.
Ibyo byongera ububasha by'amahondana.









Siyanse, pifufu...

Urishimye ?

I palanete
nziza pe



UMUSOZO