

## 7ci fgY'Cj Yfj ]Yk

#### GHJZZ7cbHJWh8YHJ]`g

#### 7cbj Ybcfg

BUa Y	9a U]`	5j U]`UV]`] <b>m</b>	@cWJhjcb	D∖cbY
6f][]htu <sup>-</sup> C`i VUg	V"c`i VUg4 i bgk "YXi "Ui	Vm'Uddc]bha Ybh	K YVghYf <sup>*</sup> &&)	

#### GWXcc~7cbhJWh~abZcfa Uhlcb

GVXcc``cZhY`5fhg`UbX`AYX]U

Fcca " %&ž@YjY`" žFcVYfhK YVghYf'6i]X]b['f) %(Ł

D\cbY. f\$&Ł'-',) '(,) \*

9a U]` gUa 4 i bgk "YXi "Ui

K YVg]hY. k k k "Ufhg"i bgk "YXi "Ui #gUa

 $\label{eq:hamiltonian} $$HY'GW.cc``cZh,Y'5ftg'UbX'AYX]U'k ci`X``]_Y'tc'FYgdYWM\cong \cong m5W_bck``YX[Y'th,Y'HfUX]tjcbU``7i gtcX]Ubg\cong hY'6YXY[U'``fPYbg]b[tcb'WJa di g\cong \cong \cong \cong mUbX'5fti/'8Yg][b'7Ua di gYg\cong \cong \con$ 

## 7ci fgY 8YHJ] g

7 fYX]hDc]bhg\*\*

Gi a a UfmcZh\Y 7ci fgY

H\]g`Wci fgY`]btfcXi WYg`mci `hc`9b[`]g\`th\fci [\`th\Y`gti XmcZ`]hYfUfmZcfa ":: cW g]b[`cb`th\Y`a U'cf``]hYfUfm [YbfYg`cZdcYtfmždfcgY`UbX`XfUa Užth\Y`Wci fgY`k]``Yl Ua ]bY`k Umg`cZk f]h]b[`]b`9b[`]g\`Zfca `U`fUb[Y`cZdYf]cXg`UbX`W`ti fU``tfUX]h]cbg`]bWi X]b[`bcb!6f]h]g\`UbX`dfY!Hk Ybh]Yth`WYbhi fm"=tik]```U`gc`]btfcXi WYmci `hc`th\Y`gdYW]U`]gYX`j cWUVi `UfmcZ`]hYfUfmUbX`hYl ti U``UbU`mg]g"

7ci fgY @YUfb]b[ 'Ci hWca Yg

%"

# 5ggYgga Ybh

 $H\YfY\ 'UfY\ 'k\ c\ 'UggYgga\ Ybhg'\ Zcf'h\ ]g'\ Wci\ fgY\ Z'YUW\ 'k\ cfh\ ')\ \$i\ '''$ 

 $H\Y'Z[fgh']g'Ub'YggUmcZ\%) $$'k cfXg'cb'Y]h\Yf'dcYhfmcf'G\U_YgdYUfYfg'Fi WXZ @[YZfffmci'W\ccgY'k \]W\CbY'mci'k Ubh'hc'k f]hY'cbE''Hcd]Wg'k ]``VY'dcghYX'cb'a ccX'Y'%$'A UfW\UbX'h\Y'YggUm]g'Xi Y'&- 'A UfW\" "$ 

 $H\Y'gYWcbX']g'U'HU\_Y!\ca Y'HYghcZ\%) $$^k cfXg'Wca df]g]b[^hk c'g\cfhfYgdcbgYgž'cbY'cb'9Xk]X[YBUbH]WUhfg'=q] 1=qS] ``$ 

#### 5XX]h]cbU`XYhU]`g.

:  $cf'h\]g'UggYgga\ Ybhhci''k\]``'k\ f]hY'hk\ c'g\cfhifYgdcbgYg'hc'ei\ Ygh]cbg'cb'=d[]\ 1=c6]''\ UbX'@a\ 8d[W\ V\ 4gf\ fZW\ ?\ ag`fS[`e"$ 

Mci 'a i gh'k f]hY 'cb 'Vch\ 'hY I hg"

 $Hcd]Wg^{*}UbX^{*}UggYgga Ybh^{*}Wf]Wf]U^{*}k]^{**}VY^{*}dcgh^{*}X^{*}da ^{*}\&^{*}5df]^{**}$ 

Gi Va ]gg]cb bchYg. Gi Va ]gg]cb ]g h\fci [ \ A ccXY

 $\label{thm:condition} \mbox{Hi fb]h]b"gYh]b" Label Carlo Carlo$ 

K YY_''‱'5df]`'!'%* 5df]`	@YWhifY	♣blfcXi Wf]cb'hc'h\Y'Bcj Y`'UbX'6Y\fci n 6ccW\Ub]ž@a 8d[W V 4gffZW? ag`fS[`e @YWi fYf.'5ggcW#DfcZG][]'>clh_UbXh
	Hi hcf]U`	6ccW.Ub]ž'@a 8dW V 4gf fZW? ag`fS[`e
K_YY_"%\$."%="5df]`"!"&' 5df]`	@YWhi fY	6ccWkUb]ž@a 8qWV 4gffZW? ag`fS[`e @YWiffYf. 5ggcWDfcZG][] >chh_UbXh
	Hi lcf]U`	6ccWkUb]ž'@a 8qW'V 4gffZW? ag`fS[`e UbX'HU_Y <ca 'dfydufuh]cb<="" td="" ua="" y'9l=""></ca>
	5ggYgga Ybh	McdW]g·Zcf·HJ_Y!\ca Y·HYghidcgHYX·*da ·&&·5df]`"

F Ygci fWYg

DfYgWf]VYX F Ygci fWYg

### Gi Va ]gg]cb cZ5ggYgga YbhHUg\_g

### Hi fb]h]b Gi Va ]gg]cb

Image: Ybwei bhyfu'dfcv'ya k \yb'uhhya dhjb[ 'hc'gi va ]hmci f'Ugg][ ba Ybhh\fci [ \ 'Hi fb]h]bz'd'YUgY

Hy'Yd\cby'9| hy'fbu''Gi ddcfhcb'-', ) '' ' ' %cf'Ya U]''h\Ya 'cb'Y! hy'fbu'hy'hgi ddcfh4 i bgk "YXi "Ui "''Gi ddcfh
\ci fg'UfY', .\$\$Ua '-'%\$.\$\$da 'cb'k YY\_XUmg'UbX'-.\$\$Ua '-').\$\$da 'cb'k YY\_YbXg'fl \*) 'XUmg'U'mYUft"'=Z'mci
UfY'i bUV'Y'hc'gi va ]hmci f'Ugg][ ba YbhXi Y'hc'U'ZJi 'hk ]h\ 'Hi fb]h]b'mci 'a UmUdd'mZcf'Ub'Y! hy'bg]cbz'Vi hmci
a i ghfYhJ]b'mci f'h]W\_Yhbi a VYf'Zfca '9! hy'fbU''Gi ddcfhfU'cb[ 'k ]h\ 'Ubmch\Yf'fy'Yj UbhXcW a Ybhgthc
]bWi XY'Ug'Yj ]XYbW' hc'gi ddcfhmci f'Y! hy'bg]cb'Udd']\WJh]cb"'=Zmci 'Ya U]''9! hy'fbU''Gi ddcfhmci 'k ]'`
Ui hca Uh]\WJ'`mfYW']j Y'U'h]\W\_Yhbi a VYfz'Vi h]Zmci 'hY'Yd\cbY'mci 'k ]``bYYX'hc'gdY\WZ]\WJ'`mUg\_'Zcf'cbY''
Hi fb]h]b'U'gc'dfcj ]XYg'i dXUhy'g'cb'h\Y]f'gmghYa 'ghUh' g'cb'Hk]hyf''

; YbYfU`mž'UggYgga YbhiHug\_g'a i ghVY'gi Va ]hhYX'Y`YVWfcb]\WJ``mij ]U'Y]h\Yf'Hi fb]h]b'cf'U'A ccX`Y Ugg][ ba Ybh''=b']bgHJb\W'g'k \YfY'h\]g']g'bchdcgg]V`Yž']hk ]```VY'gHJhYX'cb'mci f'\\circ i fgY'g'A ccX`Y'g]hY'k ]h\U`hYfbUh]j Y'gi Va ]gg]cb'XYHJ]`g"

cfi]bZcfa Uhjcbicbi\ckihcigi Va ]hUgg][ ba Ybhgicbi]bYij ]UiA ccXiY.i\hdg.#gh XYbhi bgk "YXi "Ui #\ck! gi Va ]hUgg][ ba Ybha ccXiY

# 5 WUXYa ]W<cbYghmUbX D`U[]Uf]ga

D`U[]Uf]ga i]gii g]b[ih\Yik cfXgicfi]XYUgicZch\YfgiUbXidfYgYbh]b[ih\Ya iUgimci fick b"i=hWJbihU\_Yia Ubm Zcfa gžZfca iXYi]VYfUhYiWXYUh]b[ihciUWW]XYbhU`mWcdm]b[iZfca iUigci fWYik]h\ci hiUW\_bck iYX[Ya Ybh'

IBGK [fcidg'd'U[]Uf]ga ]bhc'h\Y'Zc``ck]b['WUhY[cf]Yg.

• i bXYfgHJbX'mci f'f][\hg'UbX'fYgdcbg]V]`]h]Yg'Ug'U'gh XYbh'Uhil BGK

# 5 WUXYa ]W + DZcfa Uhjcb

: cf'YggYbhJU`gh XYbh]bZcfa UhJcb fY`UhJb[ hc.

- fYei Yghg Zcf Yl hYbg]cb/
- `UhY 'gi Va ]gg]cbg '[ i ]XY`]bYg/
- fYj ]Yk 'cZa Uf\_g/
- I BGK < YU`h\ UbX GUZYmdc`]W[Yg/
- YI Ua ]bUh]cb dfcW/Xi fYg/
- gdYWJU``Wcbg]XYfUHjcb']b'H\Y'Yj YbhcZ]``bYgg'cf'a ]gUXj Ybh fY/
- gh XYbhYei ]hmUbX'X]gUV]`]hm/
- UbX'ch\Yf'YggYbhJU`'UWUXYa ]W]bZcfa UhJcbž'gYY