

MDIA3003

DfcZYgg]cbU`DcfhZc`]c

HYfa "Hk c" ## "&\$&\$

7ci fgY'Cj Yfj]Yk

GHJZZ7cbHJWh8YHJ]`g

7cbj Ybcfg

B Ua Y	9a U]`	5j U]`UV]`] m	@cWUh]cb	D\cbY
9a a U [.] 5" [.] >UbY	Ya a U"^UbY4 i bgk "YXi "Ui	6miUddc]bha Ybh	K YVghYf*%%)	\$(%& (&-
				\$&+

GWkcc~7cbhJWh~abZcfa Uh]cb

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

Fcca ' %&ž@YjY`' žFcVYfhK YVghYf6i]`X]b[fl %(Ł

D\cbY. f\$&£'-',) '(,) *

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

K YVq]hY. k k k "Ufhq"i bak "YXi "Ui #qUa

 $\label{eq:hamiltonian} $$HY'GWCC``cZhY'5ftg'UbX'AYX]U'kci`X``]_Y'tc'FYgdYWM\cong \cong m5W_bck`YX[Y'h\Y'HfUX]tjcbU``7igtcX]Ubg\cong h\Y'6YXY[U'`fPYbg]b[hcb'WJadig\cong ix', UX][U'`fP]hmUbX'5fti/'8Yg][b'7UadigYg\cong iybUx't\Y'B[ibbUkU`dYcd'Y'fbigffU`]Ub'8YZYbW': cf\w'5\\\XYami]b'7Ub\YffU\cozh\Y'`UbXg'k\YfY'YUW\\WJadig'cZIBGK']g`c\\WJhYX''$

7ci fgY 8YHJ] g

7 fYX]hDc]bhg *

Gi a a UfmcZh\Y'7ci fgY

Gi VYWh5fYU. ? WW[S

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

%" F YgYUfWX 'UbX 'UbU'mgY 'a YX]U ']bXi glfmdfcWyggYg 'UbX 'dfUWf)Wyg"

&" @cWUhY'h\Y]f'ck b'a YX]U'dfUWfJWY'k]h\]b'h\Y'W'ffYbh'a YX]U']bXi ghfm'

' " 9ZZYWNj Y`mdfYgYbh'h\Y]f'a YX]U'dfUWNW UbX'YI dYfhjgY'hc'dchYbhjU`Ya d`cmYfg"

("FYZYWicb'h\Y'Z hifY'X]fYWIJcb'cZh\Y'a YX]U']bXi ghfmUbX']ng']a dUWicb'h\Y]f'ck b'a YX]U'dfUWIJW''

HYUWX]b[GhfUhY[]Yg

H\Y`YVWi fYg`UbX`hi hcf]U`g`]bj c`j YX`]b`A 8 =5' \$\$' `k]```\Y`d`Ybgi fY`h\UhiUg`U`h\]fX!mYUf`7 ca a i b]WUh]cbž >ci fbU`]ga `cf`Di V`]WF Y`Uh]cbg`UbX`5 Xj Yfh]g]b[`ghi XYbhmci `UfY`k Y``!Yei]ddYX`hc`gYY_Ya d`cma Ybh]b`U `Uf[Y`j Uf]YmcZ]bXi ghfmWcbhYl hg"`H\]g`Wci fgY`k]```\Uj Y`U`ghfcb[`dfUWh]WU``Wca dcbYbhk \]W\`U]a g`hc Wcbgc`]XUhY`dfYj]ci g`ghi X]Yg`UbX`\Y`d`mci `hfUbg`UhY`mci f`i b]j Yfg]hmihfU]b]b[`]bhc`]bXi ghfmUbX`Ya d`cma Ybh WcbhYl hg"`Mci `k]```UggYa V`Y`Ub`]bXi ghfmfYUXmdcfhZc`]c`UbX`XYj Y`cd`h\Y`WcbZXYbWY`hc`'''d]hW\'''`mci fgY`Z UbX`mci f`]XYUgžUg`k Y```Ug`hc`YghUV`]g\`UbX`bi fhi fY`\][\!`Yj Y`]bXi ghfmWcbhUWg"

5ggYgga Ybh

 $\label{thm:condition} $$H\YfY''HA' g'a Ybh'HJg_g'hc'Wca d'YhY'''Mci 'a i ghWca d'YhY''UbX'\UbX']b'Vch\'HJg_g']b'CfXYf'hc dUgg'h\]g'Wci fgY'''H\]g'a YUbg'h\Uhmci 'k]```ZU]`']Zmci 'Xc'bch\UbX']b'CbY'HJg_'Yj Yb']Zmci '\Uj Y'U'hc'H\' [fUXY'CZcj Yf') $'Zfca 'h\Y'Ch\Yf'lk c'Ugg][ba Ybhg''$

5ggYgga Ybh'HUg_g

5ggYgga Ybh'HJg_	K Y][\h	8i Y'8UHY	Gh XYbh@YUfb]b[Ci hWca Ygʻ5ggYggYX
∌Xi ghfmlFYUXmDfcXi Wh	(\$1	&*#\$*#&\$&\$`\$).\$\$`DA	%ž&Ž
7 ca dfY\Ybg]j Y`DcfhZc`]c`	*\$1	%(#\$, #&\$&\$`\$) .\$\$`DA	%ž&Ž Ž(

5ggYgga Ybh'8YhJ]`g

5ggYgga Ybh% ∌Xi ghfmF YUXmDfcXi Wh

GHJfhXUhY.

@Yb[h. **\$\$\$ k cfXg ftcf Yei]j U YbhŁ

8 YHJ] g.

%\$\$\$`k cfXg`fbf`Yei]j U`YbhŁ"`

Ghi XYbhg k] "fYWY] Y ZYYXVUW_i] JU Wci fgY @A G

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

GYY`Wci fgY`A ccX`Y`g]hY`Zcf`XYhJ]`g`cZh\]g`UggYgga Ybh'HJg_"`

5ggYgga Ybh& 7ca dfY\Ybg]j Y DcfhZc`]c

GhUfh XUhY.

@Yb[h\. '%a]bi hY'j]XYc'UbX'' \$\$\$!(\$\$\$ k cfXg fcf Yei]j UYblŁ

8 YHJ] g.

%a]bi hY j]XYc d]h/X UbX " \$\$\$! (\$\$\$ k cfXg fbf Yei]j U Ybh'!"

Ghi XYbhg k]``fYWY]j Y ZYYXVUW_j]U Wci fgY @A G"

5XX]h]cbU`XYhJ]`g.

 $\label{eq:GYYWC} \text{GYY'Wci} \ \text{fgY'A} \ \text{ccX'Y'g]hY'Zcf'XYhJ]`g`cZh\]g`UggYgga \ Ybh'hUg_"`$

FYgci fWyg

DfYgWf]VYX F Ygci fWYg

GYY Wci fgY g]hY cb A ccX Y"

FYWca a YbXYX FYgci fW/g

GYY Wci fgY g]hY cb A ccX`Y"

7 ci fgY '9j U'i Uh]cb 'UbX '8 Yj Y'cda Ybh

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]bž'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 Um'Udd'mZcf'Ub'Y! hy'bg]cbž'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 Ybhgt'hc
]bWi XY'Ug'Yj]XYbW' 'hc'gi ddcfhmci f'Y! hy'bg]cb'Udd']WUh]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'gdYW]Z]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 `]g`i g]b['h\Y`k cfXg`cf`]XYUg`cZch\Yfg`UbX`dfYgYbh]b['h\Ya `Ug`mci f`ck b"`±hWJb`hU_Y`a Ubm Zcfa gžZfca `XY`]VYfUhY`W\YUh]b['hc`UWW]XYbhJ``mWcdm]b['Zfca `U`gci fWY`k]h\ci hUW_bck `YX[Ya Ybh'

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

 $7 \text{ cdm}b[...i g]b[...h\Y.gUa Y.cf.j Yfmig]a] \Uf'k cfXg'hc'h\Y.cf][]bU''hYl h'cf']XYU'k]h\ci h'U\V_bck `YX[]b[...h\Y.cf][]bU''hYl h'cf']XYU'k]h'cf']$

- i bXYfglUbX`mci f`f][\hg`UbX`fYgdcbg]V]`]h]Yg`Ug`U`gh XYbh'Uhi BGK
- VY'Uk UfY'cZd`U[]Uf]ga ž'Wcdmf][\hzil BGK 'Gh XYbh7cXY'cZ7cbXi WhUbX'5WWdhUV`Y'I gY'cZ I BGK '= H'F Ygci fWfg'Dc`]Wh
- VY 'Uk UfY 'cZh\Y 'ghUbXUfXg 'cZVY\Uj]ci f'Yl dYWhYX 'cZYj YfmcbY ']b 'h\Y 'l BGK 'Wcaaib]hm
- `cWUHY 'gYfj]WYg'UbX `]bZcfa UH]cb'UVci hI BGK 'UbX'I BGK '@]VfUfm