PTRL6027

7 Ug]b['8 Yg][b'UbX'7 Ya Ybh]b[

HYfa 'C bY''##'&\$&%

7ci fgY'Cj Yfj]Yk

GHJZ:7cbHJWh:8YHJ]`g

7cbj Ybcfg

B Ua Y	9a U]`	5j U]`UV]`]hm	@cWUhjcb	D\cbY
N\]I] ⁻ 7 \Yb	n\]l]W4 i bgk "YXi "Ui	, 0	,	Ž*%'&'-',)
			@Yj Y``&ž"H9H6) % &

GWXcc`7cbHJWhi±bZcfa Uh]cb

GW.cc`cZA]bYfU`g'UbX'9bYf[mFYgcifWygC`X'AU]b'6i]`X]b[ž@YjY`'%ž%)-'fP%)Ł IBGK 'GM8B9MBGK'&\$)&5IGHF5@=5

9b[]bYYf]b['Gh XYbhGYfj]Wg'

9. a YfY"hYUW.]b[4 i bgk "YXi "Ui

 $\text{K.} \, \underline{\text{k.k.}} \, \underline{\text{Nb[]}} \, \underline{\text{bYYf]}} \, \underline{\text{b[}} \, \underline{\text{i'}} \, \underline{\text{bgk.}} \, \underline{\text{WYXi.}} \, \underline{\text{uii.}} \, \underline{\text{\#a.}} \, \underline{\text{bYfU`g!YbYf[}} \, \underline{\text{mfYgci.}} \, \underline{\text{fWg.}} \, \underline{\text{fWg.}} \, \underline{\text{mfYgci.}} \, \underline{\text{fWg.}} \, \underline{\text{mfYgci.}} \, \underline{\text{fWg.}} \, \underline{\text{mfYgci.}} \, \underline{\text{fWg.}} \, \underline{\text{mfYgci.}} \, \underline{\text{mfYgci.$

.

7ci fgY 8YHJ] g

7 fYX]hDc]bhg *

Gi a a UfmcZh\Y 7ci fgY

H\Y'Wti fgY'Wtj Yfg.

7 Ug]b['8Yg][b'! '5D=dfcdYft]Yg'cZWUg]b['UbX'WUg]b['Wci d`]b[g/dYfZcfa UbW'dfcdYft]Yg'cZWUg]b['i bXYf cUX'WcbX]t]cbg/df]bW]d`Yg'cZWUg]b['XYg][b'Zcf'j Yft]WU'zXYj]UtYX'UbX'\cf]ncbtU`k Y``g/dfYdUfUt]cb'cZWUg]b['dfc[fUa g'Zcf'X]ZYfYbhk Y``'hmdYg/cdt]a]gUt]cb'cZWUg]b['dfc[fUa "

7 Ya Ybh]b[`-'7 Ya Ybha Ubi ZJWi fYžWca dcg]h]cb`UbX`ghUbXUfX]nUh]cb/a YUgi f]b[`UbX`Wcblfc``]b[`Wla Ybh dfcdYfh]Yg/Wla YbhUXX]h]j Yg/Wla Ybhg`i ffmXYg][b/7 Ya Ybh]b[`WJ`W``Uh]cbg'! `Df]a Ufm\Wla Ybh]b[žd`i [VU`UbW]b[žUbX`gei YYnY`Wla Ybh]b[/f\Yc`c[mUbX`hmdYg`cZZck /a YW\Ub]ga `cZa i X`fYa cj U``Vm\Wla Ybh/ Wla Ybh]b[Yei]da Ybh'd`Ubb]b[žWcbXi Whb['UbX`a cb]hcf]b['df]a Ufm\UbX`gY\CbXUfm\Wla Ybh]b['cVg/dcgh cV\Wcbg]XYfUh]cbg`UbX`Yj U`i Uh]cb"

7 ci fgY 5]a g

H\]g`Wci fgY`k]``YbUV`Y`ghi XYbhg`hc`UWei]fY`Z bXUa YbhU``_bck`YX[Y`cZWUg]b[`XYg][b`UbX`W'a Ybh]b[cdYfUh]cbg`UbX`hc`Udd`mih\Y`h\Ycfmihc`h\Y`XYg][bžYj U`i Uh]cb`UbX`cdh]a]nUh]cb`cZWUg]b[`dfc[fUa`UbX W'a Ybh]b[`cdYfUh]cbg"

7 ci fgY @YUfb]b[Ci hWca Yg

52AYfigi WWggZi ``mWa d`Yh]b['h\]giWa fgYžmci ig\ci `X'VY'UV`Y'hc.

@YUfb]b['Ci HWca Y	95 GW[Y%7ca dYMbW]Yg
%":8Yg][b:UbX:Yj U`i UhY:WUg]b[:dfc[fUa:Zcf'gdYW]Z]WkY`` WcbX]h]cbg"	D9%"%ž"D9%"* ž"D9&"%ž"D9' "(
&"`8Yg][b`UbX`Yj U`i UhY`WYa Ybh]b[`cdYfUh]cbg`Zcf`gdYW]Z]Wk Y`` WcbX]h]cbg"	D9%"%ž"D9%") ž"D9&"%ž"D9' "(
' "'DfYdUfY'UbX'fYgh'WYa Ybf]b['g`i ffm'UbX'gYh'WYa Ybh'UVWcfX]b['hc 5D=gfUbXUfXg"	D9%"' ž'D9&"%ž'D9' "*

HYUWX]b['GhfUhY[]Yg'

H\]g`Wci fgY`]g`XY`]j YfYX`]b`X]gHJbWY`a cXY"`D`YUgY`fYZYf`hc`h\Y`]bZcfa Uh|cb`]b`A ccX`Y`Zcf`XYHJ]`g"

5ggYgga Ybh

5ggYgga YbhHUg_g

5ggYgga Ybh'HJg_	K Y][\h	8i Y'8UHY	Gh XYbh@YUfb]b[CihWca Yg 5ggYggYX
5gg][ba Ybh%	% \$ı	%\$#\$' #&\$&%`\$\$\$`DA	%
5gg][ba Ybh&	%) ၊	%&#\$(#&\$&%`\$\$\$`DA</td><td>%</td></tr><tr><td>5gg][ba Ybh' '</td><td>%\$ı</td><td>&%#\$(#&\$&%`\$\$\$`DA</td><td>&ž¨¹</td></tr><tr><td>C b`]bY'E i]n'</td><td>%\$ı</td><td>%*#\$(#&\$&%`\$\$\$`DA</td><td>%ž`&ž`'</td></tr><tr><td>:]bU``91 Ua '</td><td>))।</td><td>Bch5dd`]WUV`Y</td><td>%ž`&ž`'</td></tr></tbody></table>	

5ggYgga Ybh'8YHJ]`g

5ggYgga Ybh% 5gg][ba Ybh%

GhUfhXUhY. Bch5dd`]WUV`Y

8YHJ]`g.7Ug]b['dfcdYfh]Yg'UbX'`cUX'WJ`W'`Uh]cbg

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

$$\label{eq:hamiltonian} \begin{split} &\text{H}^*\text{gdYW}\text{Z}\text{WUh}\text{cbg}^*\text{UbX}^*\text{a} \text{ Uf}_\text{Jb}[\text{`fi Vf}]\text{Wg'k}]^*^*\text{VY'dfcj}]\text{XYX'Uh'h}^*\text{Y'h}\text{a} \text{ Y'cZh}^*\text{Y'Ugg}][\text{ba Ybh'fY}^*\text{YUgY''}] \end{split}$$

Gi Va]gg]cb bchYg. Cb`]bY A ccX`Y gi Va]gg]cb

Hi fb]hjb gYhjb[. H\]g]g bchU Hi fb]hjb Ugg][ba Ybh

5ggYgga Ybh& 5gg][ba Ybh&

GhUfhXUhY. Bch5dd`]WUV`Y

8YHJ]`g. 7 Ug]b['dfc[fUa 'XYg][b'

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

 $\label{eq:hamiltonian} $$HY'gdYWJZJWUh]cbg'UbX'a\ Uf_]b['fi\ Vf]Wg'k\]``VY'dfcj\]XYX'Uh'h\Y'h]a\ Y'cZh\Y'Ugg][\ ba\ Ybh'fY`YUgY''] $$$

Gi Va]gg]cb bchYg. Cb`]bY A ccX`Y gi Va]gg]cb

Hi fb]hjb gYhjb[. H\]g]g bchU Hi fb]hjb Ugg][ba Ybh

5ggYgga Ybh' . 5gg][ba Ybh'

8YHJ]`g.7YaYbh]b['WJ`W'`Uh]cbg

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

H\Y`gdYWJZJWUhJcbg`UbX`a Uf_]b[`fi Vf]Wg`k]``VY`dfcj]XYX`Uh'h\Y`hJa Y`cZh\Y`Ugg][ba Ybh'fY`YUgY"

Gi Va]gg]cb bchYg. 'C b`]bY A ccX`Y gi Va]gg]cb

Hi fb]hjb gYhjb[. H\]g]g bchU Hi fb]hjb Ugg][ba Ybh

5ggYgga Ybh(. Cb`]bY Ei]n

@Yb[h\.'%'\cif

8YHJ]`g.7cjYfg`gY`YWYX`Wcbh/bhcZWUg]b[`XYg][b`UbX`WYaYbh]b[

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

Cb`]bY'ei]nnYg'k]``'hYgh'h\Y'i bXYfgh'bX]b['cZh\Y'a UhYf]U``cZh\Y'Wcj YfYX'hcd]Wg'h]```XUhY'''; YbYfU``Zcfa Uh'cZ Vch\'h\Y'ei]nnYg'k]``'VY'U'Wca V]bUh]cb'cZa i `h]d`Y!W\c]WY'ei Ygh]cbg'UbX'g\cfhfYgdcbgY'ei Ygh]cbg fYei]fYX'hc'VY'gi Va]hhYX']b'U'dfY!XYZ]bYX'Xi fUh]cb"

Gi Va]gg]cb bchYg. Cb`]bY A ccX`Y gi Va]gg]cb

Hi fb]hjb gYhjb[. H\]g]g bchU Hi fb]hjb Ugg][ba Ybh

5ggYgga Ybh) :]bU`9l Ua

GHJfhXUhY. Bch5dd`]WUV`Y

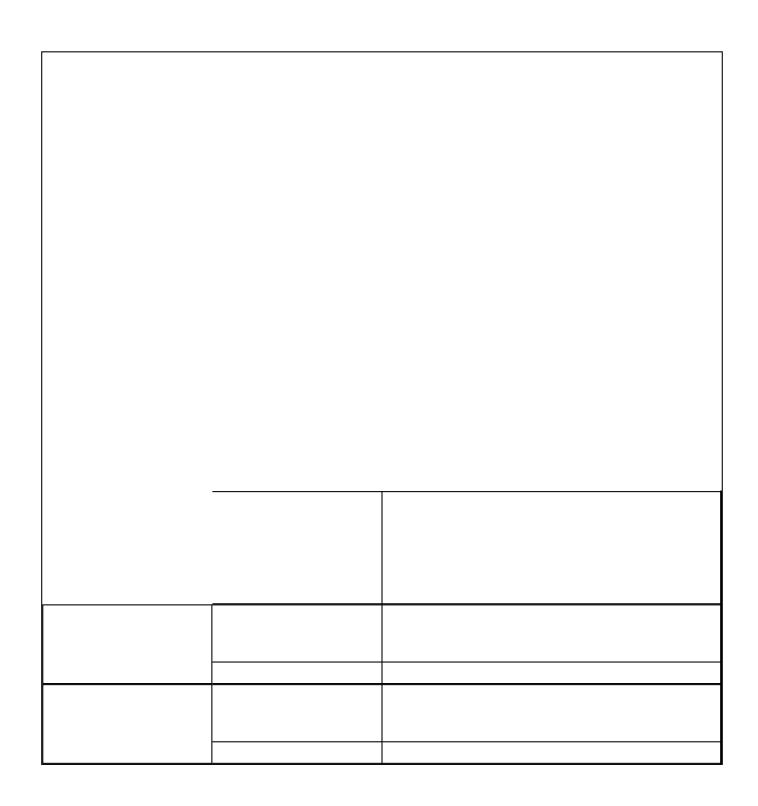
@Yb[h\. '&'\ci fg

8YHJ]`g.7cjYfg'U```WcbHYbhcZWUg]b['XYg][b'UbX'WYa Ybh]b[

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

Gi Va]gg]cb bchYg. Cb`]bY A ccX`Y Gi Va]gg]cb

Hi fb]hjb gYhjb[. H\]g]g bchU Hi fb]hjb Ugg][ba Ybh



FYgci fW/g

DfYgWf]VYX F Ygci fWYg

Gi ddcfha UhYf]U`Zcf'h\]g'Wci fgY`]bWi X]b[ž'k \YbYj Yf'Uj U]`UV`Yž'Wcd]Yg'cZ`YWi fY'bchYgžj]XYc'W]dgž `YWi fY'fYWcfX]b[gž'fYWca a YbXYX'fYUX]b[gž'YhW''Wbb'VY'Zci bX'cb'A ccX`Y" H\Y``YWi fY'bchY'a UmVY'j]Yk YX'UbX'Xck b`cUXYX'Zfca 'h\Y'l BGK !A ccX`Y \hd.##a ccX`Y"hY`h'i bgk "YXi "Ui #

FYWca a YbXYX FYgci fWyg

: c c b [b[g] UfY b Y fYWta a YbXYX Vcc_g Zcf 7 Ug]b[8 Yg][b.

- F U\a Ub'G"G"'UbX'7\]']b[Uf]Ub'; "J ".'7 Ug]b['8Yg][b'H\Ycfm'UbX'DfUWj\W'''9'gYj]Yf'GW]YbW' 6"J "ž'5a ghYfXUa ž'H\Y'BYh\Yf'UbXgž'%-) "
- 6ci f[cmbY :5"H"'>f"žA]``\Y]a :? "? "ž7\YbYj YfhA "9"'UbX'Mci b[:: "G"'>f". '5dd`]YX'8f]``]b[
 9b[]bYYf]b[žGD9 'HYI Wcc_'GYf]YgžJ c`"'&žF]W.UfXgcbž'HL žI G5ž'% %"

 $HY'HYI'Wcc_{Zc}f'7YaYbh]b[']g.$

BY`gcbž'9"6"'UbX'; i]``ch8"ž'K Y```7 Ya Ybh]b['fGYWcbX'9X]h]cbłż'GW\`i a VYf[

‰

a]gg]cb cZ5ggYgga YbhHUg_g

Wkcc``\UgʻXYjY`cdYX`U`[i]XY`]bY`hc`\Y`d`mci`k\YbʻgiVa]hhjb['U`WcifgY`Ugg][baYbh'

pWci fU[Y'mci 'hc'fYhU]b'U'WcdmicZYj YfmiUgg][ba Ybhigi Va]hhYX'Zcf'UggYgga Ybh'Zcf'mci f'ck b'fYWcfX i']b'\UfXWcdmicf'Y`YWffcb]WZcfa "

gYgga Ybhgʻa i ghi\Uj YʻUbʻUggYgga YbhWcj Yfʻg\YYhUHUWXYX".

fgY Wca d`Yh]cb

pY Wead `Yhjeb fYei]fYg gi Va]gg]cb cZU``UggYggaYbh]hYag": U]`ifY he gi Va]hU``UggYggaYbh]hYag Ygi`h]b h\Y Uk UfX cZUb I bgUhjgZJWefm: U]`ifY fI: E[fUXY Zef h\Y 7 cifgY ib`Ygg gdYWJU` XYfUhjeb \Ug VYYb gi Va]hhYX UbX UddfejYX" D`YUgY behYž U WeadYhYbWn\ifX`Y cZ)\$i]g Udd`]YX he pU`UggYggaYbh'

' Gi Va]gg]cb cZUb 5gg][ba Ybh

Uf_g`Zcf`Ub`Ugg][ba Ybh'UfY`cb`mdcgg]V`Y`k\Yb`Ub`Ugg][ba Ybh']g`fYV\Y]j YX`Vmh\Y`Xi Y`XUhY"`

bXYfgHUbX`H\Un'Uh'Hja Yg`mci `a Umbch`VY`UV`Y`hc`gi Va]h`Ub`Ugg][ba Ybh`cb`Hja Yž`UbX`H\Y`GW\cc``k]`` La cXUHY`UbmZJ]f`UbX`fYUgcbUV`Y`YI HYbg]cb"`K Y`k ci `X`fYWca a YbX`mci `fYj]Yk `H\Y`I BGK `GdYWJU` |XYfUHjcb`[i]XY`]bYg`—`gYY`gYWfjcb`VY`ck"

gi Va]gg]cb'k]``bchVY'UWWdhYX'UbX'k]``VY'Wcbg]XYfYX'Ug'bc'gi Va]gg]cb"

W]U`7cbg]XYfUh]cb

Wb`Udd`m'Zcf`gdYWJU``Wcbg]XYfUh]cb`h\fci[\<u>H\Y`BiWYig`GhXYbh<iV</u>`k\Yb`]``bYgg`cf`ch\Yf ghUbWfg`]bhYfZYfY`k]h\`mcif`UggYggaYbhdYfZcfaUbWf"`G]W_bYggža]gUXjYbhifY`cf`ch\Yf ghUbWfg`VYmcbX`mcif`Wcbhfc``aUm

/ DfYj Ybhmci 'Zfca 'Wca d`Yh]b['U'Wci fgY'fYei]fYa Ybh / DYYd'mci 'Zfca 'UhYbX]b['Ub'UggYggUV`Y'UW]j]hm

Ya]hh]b['UggYggUV'Y'k cf_'Zcf'U'Wci fgY

ZYWimci fidYfZcfa UbWY]biUggYggUV`Yik cf_žVYi]hUiZcfa U``YbX!cZgYa YgHYf WUggiHyghžU``UVcfUhcfmHyghžUigYa]bUfidfYgYbHUhjcbicfiUbmich\YfiZcfa icZ

YUgY`WcbHUWfih\Y`7 ci fgY`7 cbj Ybcf`]a a YX]UhY`mcbWY`mci `\Uj Y`Wca d`YhYX`h\Y`gdYW]U` odd`]WUh]cbž'bc``UhYf'h\Ub`cbY`k YY_`Zfca `gi Va]gg]cb"

A cfY`XYhJ]`g`cb`gdYVJJU``Wcbg]XYfUh]cb`WJb`VY`Zci bX`Uh`k k k "ghi XYbh'i bgk "YXi "Ui #gdYVJJU`!Vcbg]XYfUh]cb

- I BGK '@YUfb]b['7YblfY'! '<u>k k k "'Wi bgk "YXi "Ui</u>
- 7 ci bgY``]b['gi ddcfh! 'k k k "Wti bgY``]b["i bak "YXi "Ui

9ei]Huv`Y`@YUfb]b[`GYfj]WYg`U]a gʻhcʻdfcj]XY`U```ghi XYbhgʻk]h\`U`ZYYY`UbX`WcbZ]XYbh]U``gYfj]WY`h\Uh dfcj]XYg'dfUWh]WU``gi ddcfhihc Ybgi fY`h\Uhmci f`\YU`h\`WcbX]h]cb`XcYgbfhiUXj YfgY`mUZZYWhimci f`ghi X]Yg''`\hdg.##ghi XYbh'i bgk "YXi "Ui #Y`g

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

Mci f`YWi fYf'UbX'h\Y'I b]j Yfg]lmk]``YI dYWimci f`gi Va]lhYX'Ugg][ba Ybhg'UfY'lfi `mmci f`ck b'k cf_"'I BGK \Ug'j YfmWYUf'[i]XY`]bYg'cb'k \Uhd`U[]Uf]ga ']g'UbX'\ck 'hc'Uj c]X']h'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"'D`U[]Uf]ga ']g'U'mdY'cZ]bhY``YWi U`'h\YZh''±i\Wb'hU_Y a UbmZcfa gžZfca 'XY`]VYfUhY'W\YUh]b['hc'UW]XYbhU``mWcdm]b['Zfca 'U'gci fW'k]h\ci hUW_bck `YX[Ya Ybh' H\Y'I b]j Yfg]lm\Ug'UXcdhYX'Ub'YXi WUh]j Y'UddfcUW\ 'hc'd`U[]Uf]ga 'UbX'\Ug'XYj Y`cdYX'U'fUb[Y'cZ fYgci fW'g'hc'gi ddcfhghi XYbhg"'5``h\Y'XYhU]`g'cb'd`U[]Uf]ga ž]bWi X]b['gca Y'i gYZ ``fYgci fW'gžWUb'VY Zci bX'Uhk k k "qhi XYbhi bak "YXi "Ui #d`U[]Uf]ga "

 $5 ```A]b]b["9b[]bYYf]b["ghi XYbhg"UfY"fYei]fYX"hc "Wca d`YhY"U"ghi XYbhXYWUfUh]cb" Zcf"UWUXYa]W]bhY[f]hm k \]W.]g"ci h]bYX']b"h\Y"Ugg][ba YbhWcj Yf"g\YYhg""6mg][b]b["h\]g"XYWUfUh]cbž"mci "U[fYY"h\Uh'mci f"k cf_"]g mci f"ck b"cf][]bU"k cf_"$

⊋mci 'bYYX'gca Y'UXX]h]cbU``gi ddcfhk]h\ 'mci f`k f]h]b['g_]``gž'd`YUgY'WcbhUWh\Y'@YUfb]b['7 YbhfY'cf'j]Yk gca Y'cZh\Y'fYgci fWg'cb'h\Y]f`k YVg]hY. 'k k k "`Wi bgk "YXi "Ui "'H\Y'@YUfb]b['7 YbhfY']g'XYg][bYX'hc'\Y`d mci ']a dfcj Y'mci f'UWUXYa]Wk f]h]b['UbX'Wca a i b]WUh]cb'g_]``g"'Gca Y'ghi XYbhg'i gY'h\Y'7 YbhfY'gYfj]W/g VYWUi gY'h\YmUfY'Z]bX]b['h\Y]f'Ugg][ba Ybhg'U'W\U``Yb[Yžch\Yfg'VYWUi gY'h\Ymk Ubhhc']a dfcj Y'Ub'U`fYUXm gi WW/ggZ ``UWUXYa]WdYfZcfa UbW/"

5W_bck `YX[Ya YbhcZ7ci bhfm

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