

MUSC3705

DYfZcfa UbW @UVcfUhcfm7

HYfa 'H\fYY''##'&\$%-

7ci fgY'Cj Yfj]Yk

Ghuzz 7 cbhuWh8 Yhu]`g

'7cbj Ybcfg'

B Ua Y	9a U]`	5j U]`UV]`] m	@cWUhjcb	D\cbY
>c\b^BUd]Yf	3 0	H65"!"WXYW <u>_</u> "h\Y A ccX`Y"g]hY	KYVghYf*%%	-',)*-)'

"@YWhifYfg"

B Ua Y	9a U]`	5j U]`UV]`] m	(ar VVIIInch	D∖cbY
>Ygg [·] 7]Ua dU	gUa 4 i bgk "YXi "Ui			

GWXcc`7cbHJWhi±bZcfa Uhjcb

Fcca " &ž`Yj Y`" FcVYfhK YVghYf`6i]`X]b[

D\cbY. f\$&£'-',) '(,)*

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

K YVg]hY. '\hdg.##gUa "Ufhg"i bgk "YXi "Ui

 $\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``7i gtcX]Ubgž h\Y'6YXY[U'`fPYbg]b[tcb'WJadigŁZ'; UX][U'`fP]tmUbX'5fth/'8Yg][b'7UadigYgŁ'UbX'h\Y'B[ibbUkU`dYcd'Y'fbigffU]Ub'8YZYbW': cfW'5WJXYam]b'7UbVYffUŁ'cZh\Y'`UbXg'k\YfY'YUW\'WJadig'cZlBGK']g`cWJhYX''$

7 ci fgY 8 YHJ]`g 7 fYX]hDc]bhg (' Gi a a UfmcZh\Y 7 ci fgY

fYdcfhg"

5ggYgga Ybh' . DYfZcfa UbWY#JfYgYbHJh]cb

GhUfh'XUhY.

8YHJ]`g. 'H\fYY`]b!WUgg'dYfZcfa UbWYg'gWUZC`X]b['UggYgga YbhiHJg_'("Gdc_Yb'ZYYXVUW_'k]``'VY`[]j Yb'Vm h\Y'`YWi fYf']b'WUggž'UbX'k f]HYb'ZYYXVUW_'q\cfhmUZYf

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

Ghi XYbhgʻk]``[]j YʻUʻa]b]a i a ˈcZcbYˈga U``[fci dˈdYfZcfa UbWlʻ]bʻH½čUbXˈhk cˈga U``[fci dˈdYfZcfa UbWl'g]bʻH'

Hi fb]hb gYhb[. H\]g]g bchU Hi fb]hb Ugg][ba Ybh

5ggYgga Ybh(.:]bU`Dfc YWh

GHJfhXUhY.

8YHJ]`g. ; fci d`dYfZcfa UbWY`cf`di V`]Wmig\ck b`j]XYc"`K f]HYb`ZYYXVUW_`k]```VY`dfcj]XYX`Vmh\Y YI Ua]bYffqŁ`

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

Ghi XYbhgʻk]``k cf_`]bʻUʻga U```[fci dʻhcʻWfYUHYʻUʻdYfZcfa UbWYʻcZ%\$!%) ʻa]bi hYgfiXi fUh]cb"·H\]gʻa Um`VY
[]j YbʻUgʻU``]j YʻdYfZcfa UbWYʻcfʻUgʻUʻj]XYc"·H\YʻdfYgYbHUh]cbgʻk]```VY`\Y`X`Y]h\Yf`]bʻK YY_'%\$ž`]bʻh\Yʻi gi U`
`YWhi fYʻh]a Yžcfʻ]bʻUʻqYdUfUhYʻYj Ybhžqi VYWhibcʻUffUb[Ya Ybhik]h\`h\Yʻ7 fYUh]j YʻDfUWNWY@UVcfUhcfm"

F Ygci fWg

DfYgWf]VYX F Ygci fWYg

BchUjU]`UV`Y

FYWca a YbXYX FYgci fWfg

BchUj U]`UV`Y

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

UV h 7 cifgYg\ 'h\ g\ Yj Y` 7 Ub Yg\ b `i `; 'U` Y ; `U g\ Y

cb i f] Wca cbYbb 'UbX' \Y' Yf]fY Ybb' ; \Y' g Yb] Ygh 'b'U f]cb

g ifg j d cUWX; h ; Ub] i Ybb' cU g\ bX' YYXVUW

Gi Va]gg]cb cZ5ggYgga YbhHUg_g

Gi Va]gg]cb cZ5ggYgga YbhHUg_g

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±i\WbihU_Yia Ubm Zcfa gžZfca iXYi]VYfUhYiW\YUh]b[ihciU\W]XYbhU`m\Wcdm]b[iZfca iUigci f\Wik]h\ci hiU\w_bck iYX[Ya Ybh'

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

7 cdm]b[.'i g]b['h\Y'gUa Y'cf'j Yfmg]a]`Uf'k cfXg'hc'h\Y'cf][]bU`hYl h'cf']XYU'k]h\ci h'UW_bck `YX[]b['h\Y gci fW'cf'i g]b['ei chUh]cb'a Uf_g"'H\]g'U`gc'Udd`]Yg'hc']a U[Ygž'Ufh'UbX'XYg][b'dfcYWhgž'Ug'k Y``'Ug dfYgYbhUh]cbg'k \YfY'gca YcbY'dfYgYbhg'Ubch\Yf'g']XYUg'cf'k cfXg'k]h\ci h'WfYX]h'

⇒ Uddfcdf]UhY 'dUfUd\fUg]b[. '7\Ub[]b['U'ZYk'k cfXg'UbX'd\fUgYg'k\]Y 'a cghmfYhU]b]b['h\Y'cf][]bU`ghi Wh fY 'UbX#cf'dfc[fYgg]cb'cZ]XYUg'cZh\Y'cf][]bU`žUbX']bZcfa Uh]cb'k]h\ci hUW_bck`YX[Ya Ybh'H\]g'U`gc Udd`]Yg']b'dfYgYbhUh]cbg'k\YfY'gca YcbY'dUfUd\fUgYg'Ubch\Yf'g']XYUg'cf'k cfXg'k]h\ci h'WfYX]h'UbX'hc d]YW]b['hc[Yh\Yf'ei chYg'UbX'dUfUd\fUgYg']bhc'U'bYk'k\c`Yžk]h\ci h'Uddfcdf]UhY'fYZYfYbW]b['"

7 c``i g]cb.'k cf_jb['k]h\ch\Yfg'Vi hdUgg]b['cZZh\Y'k cf_'Ug'U'dYfgcb'g']bX]j]Xi U``k cf_"'7 c``i g]cb'U`gc]bWi XYg'dfcj]X]b['mci f'k cf_'hc'Ubch\Yf'ghi XYbhVYZcfY'h\Y'Xi Y'XUhYžcf'Zcf'h\Y'di fdcgY'cZh\Ya d`U[]Uf]g]b['UhiUbmh]a Yž'dUm]b['Ubch\Yf'dYfgcb'hc'dYfZcfa 'Ub'UWUXYa]WhUg_ž'ghYU']b['cf'UWei]f]b[Ubch\Yf'dYfgcb'g'UWUXYa]Wk cf_'UbX'Wcdm]b[']hz'cZYf]b['hc'Wca d'YhY'Ubch\Yf'dYfgcb'g'k cf_'cf'gYY_]b[dUma YbhZcf'Wca d'Yh]b['UWUXYa]Wk cf_"

±bUddfcdf]UhY`W]hUh]cb.`7]h]b[`gcifWrg`k\]W\`\UjY`bchVYYb`fYUXžk]h\cihUW_bck`YX[]b[`h\Y`´gYWcbXUfm´gcifWrZfca`k\]W\`_bck`YX[Y`cZh\Ya`\Ug`VYYb`cVhU]bYX"

8 i d`]\WUh]cb`ffgY`Zd`U[]\Uf]ga "Ł gi Va]\h]b[`mci f`ck b`k cf_ž]b`k \c`Y`cf`]b`dUfhžk \YfY`]h\Ug`dfYj]ci g`m VYYb`dfYdUfYX`cf`gi Va]\hYX`Zcf`Ubch\Yf`UggYgga Ybhcf\Wci fgY`UhI BGK `cf`Ubch\Yf`i b]j Yfg]\m'

7 cffYWnfYZYfYbWlb['dfUWnWyg.

• DUfUd\fug]b[z'gi a a Uf]q]b[z'YggUmk f]hb['UbX'ha Y'a UbU[Ya Ybh