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 $\label{eq:hamiltonian} $$HY'GWKcc``cZhY'5ftg'UbX'AYX]U'kci`X``]_Y'hc'FYgdYWM\cong \cong m5W_bck`YX[Y'h\Y'HfUX]hjcbU``7ighcX]Ubgžh\Y'6YXY[U'`fPYbg]b[hcb'WJadigŁž'; UX][U'`fP]hmUbX'5fh\/'8Yg][b'7UadigYgŁ'UbX'h\Y'B[ibbUkU`dYcd'Y'fbighfU`]Ub'8YZYbW': cf\W'5\WJXYam]b'7UbVYffUŁ'cZh\Y'`UbXg'k\YfY'YUW\'WJadig'cZIBGK']g`c\WJhYX''$

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H\]g`Wci fgY`YI Ua]bYg`h\Y`bUhi fY`cZa i g]WUg`"ffUX]h]cb"ž]bj Ygh][Uh]b[`X]gWci fgYgžj U`i Yg`UbX`i gYg`cZa i g]Wh\UhYbXi fY`cf`W\Ub[Y`UhiU`X]ZZYfYbhfUhY`UbX`]b`X]ZZYfYbhk Umg`Zca `a i g]WU``Zcfa g`h\Ya gY`j Yg" 9I Ua]b]b[`h\Y`XYj Y`cda YbhcZcbY`cf`a cfY`a i g]WU``W`hi fYgž'h\Y`Wci fgY`k]``XYa cbghfUhY`\ck `[YbfYgž k cf_g`UbX`dYfZcfa UbW\g`Ya VcXmUbX`[YbYfUhY`a YUb]b[`h\fci [\`h\Y]f`fY`Uh]cbg\]d`hc`Wca a i b]hm]b gdYW]ZJW\]ghcf]WU``ZgcW]U`Z`UbX`dc`]h]WU``WcbhYI hg" 5 ZZYWhUbX`UYgh\Yh]Wg`ZWfYUh]j]hmUbX`Wc[b]h]cb`Z Ya VcX]a YbhUbX`a Ya cfmžfYWdh]cb`UbX`hfUbga]gg]cb`ZUbX`dYfZcfa UbW\`UbX`f]hi U``UfY`gca Y`cZh\Y dcgg]V`Y`h\Ya Yg`h\UhYbhYf`h\Y`YI Ua]bUh]cb`cZ\ck `a i g]WWca a i b]hmfY`Uh]cbg\]dg`UbX`]bhYffY`UhYX a YUb]b[g`UfY`fYhU]bYX`cf`a cX]Z]YX`]b`h\Y`WcbhYI hg`cZa cXYfb]gUh]cb`z[`cVU`]gUh]cb`UbX`a][fUh]cb"`H\Y Wci fgY`]bj Ygh][UhYg`\ck `UbX`k \mžUg`bYk `Zcfa g`UfY`XYj Y`cdYXžgca Y`VYWca Y`Ub`YbXi f]b[`ZYUhi fY`cZU a i g]WU``W``hi fYžk \]Y`ch\Yfg`UfY`i gYXžj U`i YXžh\Yb''hYb''ffUg\YX'`Ug`fYXi bXUbh'i

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- %" I bXYfgHJbX`h\Y`UZYWfjjY`VUgYg`UbX`\]ghcf]WJ`ž'gcWJU``UbX`dc`]hJWJ``WcbhYI hg`cZh\Y`XYjY`cdaYbhcZ cbY`cf`acfY`aig]WW`hifYg"
- &" 5dd`m_bck `YX[Y`cZh\Y`]XYUg`UbX`]XYc`c[mcZhfUX]hJcb`hc`h\Y`gh XmcZa i g]WUbX`hc W`hi fY`a cfY`VfcUX`m"
- ' " 5 bU`mgY`UbX`X]gW gg`h\Y`]a dUWficZa cXYfb]gUh]cbž[`cVU`]gUh]cb`UbX`a][fUh]cb`cb`h\Y XYj Y`cda YbhcZa i g]WU`dfUWfWY`UbX`a YUb]b["

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9 I dYWWYX fYgci fWYg 'k]``VY 'a UXY 'Uj U]`UV`Y 'cb`]bY 'j]U 'h\Y '`]VfUfmUbX 'ch\Yf 'UWWYgg]V`Y 'g]hYg"'D`YUgY 'gYY A ccX`Y 'Zcf`XYHJ]`g"

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 $: YYXVUW_cb"h\Y'Gma~dcg]i~a~"dfYdUfUh]cb"UbX'Z]bU``gi~Va~]gg]cb"k~]```VY"j~YfVU``fKi~f]b[~`WUgg"Ug"bYW'ggUfmLUbX"k~f]hhYb"":~YYXVUW_cb"]b!WUgg"UW']j~]h]Yg"k~]``~]a~a~YX]UhY`m'Zc"`ck~`WUgg'dfYgYbhUh]cbg"$

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\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'Yl 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 Ybhgthc
]bWi XY'Ug'Yj]XYbW'hc'gi ddcfhmci f'Yl 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"

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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.

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