

ARTS2128

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 $\label{eq:hamiltonian} $$HY'GWKcc``cZhY'5ftg'UbX'AYX]U'kci`X``]_Y'tc'FYgdYWM\cong \cong m5W_bck`YX[Y'h\Y'HfUX]tjcbU``7i gtcX]Ubg\cong h\Y'6YXY[U'`fPYbg]b[tcb'WJa di g\cong tz'; UX][U'`fP]tmUbX'5fth/ '8Yg][b'7Ua di gYg\cong tubX't\Y'B[i bbUk U` dYcd'Y'fbi gtfU']Ub'8YZYbW': cf\w'5\\WXYa m']b'7UbVYffU\cozh\Y'`UbXg'k\YfY'YUW\cozh\Y'YUW\cozh\Y''UbXg'k\YfY'YUW\cozh\Y'' \cozh\Y''\UbXg'k\YfY'YUW\cozh\Y'' \cozh\Y''\UbXg'k\YfY'YUW\cozh\Y'' \cozh\Y''' \cozh\Y'''' \cozh\Y''' \cozh\Y'''' \cozh\Y''' \cozh\Y'' \cozh\Y'' \cozh\Y''' \cozh\Y'' \cozh\Y'' \cozh\Y''' \cozh\Y'' \cozh$

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5 frjgrjWghfUhY[]Yg`\Uj Y`Ya Yf[YX`Ug`dck YfZ `a YUbg`cZa U_]b[`gcWjU``UbX`dc`]rjWU``a YggU[Yg`\YUfX`VmU k]XYf`Ui X]YbWYž'UbX`ghfUhY[]Yg`gi W\`Ug`W``hi fY`'Ua a]b[žZUg\`a cVgž[i Yff]``U'h\YUhfYž'UbX`cb`]bY UWjj]ga `\Uj Y`\UX`Ub`]a dUWhUwfcgg`dc`]rjWU``WJa dU][b]b[žgcWjU``UXj cWUwhž'UbX`Wca a i b]hma cV]`]gUhjcb" H\]g`Wci fgY`k]``]bhfcXi WY`mci 'hc`gca Y`cZh\Y`_Ym\]ghcf]WU``XYj Y`cda Ybhg`UbX`XYVUhYg`Ufci bX`\ck 'Ufh \Ug VYYb'i gYX`hc`]bgd]fY`W\Ub[Y`UbX`hc]bhYfj YbY`k]h\]b'di V`]WgdUWY"'\nci k]``\Uj Y`h\Y`W\UbWY`hc`k cf_ k]h\`mci f'dYYfg'hc`XYj]gY`mci f'ck b'Zcfa 'cZUWfj]ga 'cf`Wca a i b]hmYb[U[Ya Ybh'Ufci bX`Ub`]ggi Y`cZmci f W\c]WY"'H\]g`Wci fgY`]g'dUfhcZh\Y`H\YUhfY`UbX`DYfZcfa UbWY`Ghi X]Yg`ghfYUa "`\#h\WUb`U`gc`VY`hU_Yb`Ug`Ub Y`YWfj Y`]b'h\Y`6U\XY`cf`cZA YX]U'fDi V`]WF Y`Uhjcbg`UbX`5Xj Yfhjq]b[Ł"

7 ci fgY @YUfb]b[Ci hWca Yg

- %" ⇒ XYbhjZmg][b]Zj\Wbha ca Ybhg`UbX`XYVUhYg`]b`h\Y`XYj Y`cda YbhcZdi V`]\WUfhz`U\Wjj]ga z`UbX`h\Y dc`]hJ\Wg`cZdi V`]\WgdU\W`]b`h\Y`&\$h\`UbX`&\gh\\Wbh f]Yg```
- &" 5ggYgg`_Ymh\YcfYh]WU``WcbWYdhg`Ug`k Y```Ug`dfUWf]WU``a cXYg`cZUWf]j]ga `UbX`di V`]WUk UfYbYgg! fU]q]b[ž'UbX`Udd`mih\Ya 'hc`WcbhYa dcfUfm]qqi Yq```
- ' "Kcf_Wc``UVcfUhjjY`mk]h\ch\Yfg`]b`ibXYfhU_]b[`fYgYUfWX`UbX`dfYgYbhUhjcbcZZ]bX]b[g```

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F YUX]b[gžj]XYcgž UbX 'U'Wca V]bUh]cb 'cZcb']bY 'UbX 'ZJWY!hc! ZJWY ''YWi fYg'k]``'dfcj]XY '\]ghcf]\W\' '\WcbhYl h UbX '\Wf]h]\W\' '\H'fa]bc 'c[m\Zcf'i bXYfghUbX]b['h\Y'j Uf]ci g']bhYffY`Uh]cbg 'VYk YYb 'UfhUbX 'U\Wj]]ga "''5 Z]ddYX a cXY`'cZhi hcf]U`g'k]``'gi ddcfhighi XYbh'YX'Yb[U[Ya Ybhik]h\']ggi Yg'UbX '\WgY'ghi X]Yg'cZh\Y]f'ck b \\\ccg]b[z``YUX]b['hck UfX'h\Y'XYj Y`cda YbhcZh\Y'Z]bU`'[fci d'dfc Y\Wih\UhXYj]gYg'U'k Umhc'a cV]`]gY'di V`]\\\UhXYbYgg'Ufci bX'U'\W ffYbh']ggi Y"

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5ggYgga Ybh& 7UgY Gh Xm

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@Yb[h\. '\&\$\$!\%) \$\$ k cfXg

8YHJ]`g. Mci 'UfY'Ug_YX'hc'XYa cbglfUhY'Uddfcdf]UhY`mgY`YWYX'h\Ycf]Yg'UbX'WcbW'dhg'Zfca 'h\Y'Wci fgY']bfY`Uh]cb'hc'Ub']bXYdYbXYbh`mfYgYUfW\YX'WJgY'ghi Xm'\&) \$!\%) \$\$'k cfXg'': YYXVUW_j]U'Hi fb]h]b''

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GhUfh'XUhY.

8 YHU]`g. 'K cf_']b'ga U```[fci dg'hc'XYj]gY'U'Zcfa 'cZUWlj]ga ždYfZcfa UbW'žcf'a cV]`]nUhJcb"'H\]g'UWlJcb'a Um fYa U]b'WcbW'dhi U``Vi hg\ci `X'VY'XYHU]`YX']b']hg'd`Ub'Zcf'Yl YW hJcbžUbX'g\ci `X'VY'VUgYX'cb'Vch\'df]a Ufm UbX'gYWcbXUfmfYgYUfW\']bhc'U'WcbhYa dcfUfm]ggi Y"'9UW\'[fci d'k]``'dfcXi W''U'Zcfa 'cZXcW'a Ybhih\Uh]g Uddfcdf]UhY'hc'h\Y'UWJcb"9UW\'ghi XYbhk]``'fYWY]j Y'k f]hYb'ZYYXVUW_cb'h\Y'cj YfU```[fci d'dfcYWhUbX'cb

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5bX'h\Y'k YVq]hYq'UfY'O\hd.##/YUi hZ `ffci V`Y"cf[2'UbX'O\hda.##/YUi hZ `f]a]b["cf[#2

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HY'Yd\cbY'9| h/fbu''Gi ddcfhcb'-',) '' ' ' %cf'Ya U] 'h\Ya 'cb'Y! h/fbu'h/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'mYUfŁ" Image: 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! h/bg]cbž'Vi hmci
a i ghfYhJ]b'mci f'h/W_Yhbi a VYf'Zfca '9! h/fbU''Gi ddcfhfU'cb['k]h\ 'Ubmch\Yf'YY] UbhXcW a YbhgŁ'hc
]bWi XY'Ug'Yj]XYbW' 'hc'gi ddcfhmci f'Y! h/bg]cb'Udd']WJh/cb" Image: Ya U]''9! h/fbU''Gi ddcfhmci 'k]'`
Ui hca Uh/WJ'mfYW'] Y'U'h/W_Yhbi a VYfž'Vi h]Zmci 'hY'Yd\cbY'mci 'k]'`'bYYX'hc'gdYW/ZWJ'`mUg_'Zcf'cbY''
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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"'\lefi\Wb'hU_Y`a Ubm Zcfa gžZfca `XY`]VYfUhY`W\YUh]b['hc`UVW]XYbhU`mWcdm]b['Zfca `U`gci f\W' k]h\ci hUW_bck `YX[Ya Ybh'

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7 cdm]b[.'i g]b['h\Y'gUa Y'cf'j Yfmg]a]`Uf'k cfXg'hc'h\Y'cf][]bU`h\I hcf']XYU'k]h\ci hUW_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'dfc YWhgž'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 cghmfYhJ]b]b['h\Y'cf][]bU`gffi WhifY 'UbX#cf'dfc[fYgg]cb'cZ]XYUg'cZh\Y'cf][]bU`ž'UbX']bZcfa UhJcb'k]h\ci hUW_bck `YX[Ya Ybh''H\]g'U`gcUdd`]Yg']b'dfYgYbhUhJcbg'k\YfY'gca YcbY'dUfUd\fUgYg'Ubch\Yf'g']XYUg'cf'k cfXg'k]h\ci hWfYX]h'UbX'hc

5 WUXYa]W±bZcfa Uhjcb

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