

MUSC2803

7 fYUhjj Y'Gci bX'HYW\bc\c[]Yg

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

7ci fgY'Cj Yfj]Yk

Ghuzz 7 cbhuWh8 Yhu]`g

'7cbj Ybcfg'

B Ua Y	9a U]`	5j U]`UV]`]m	@cWJhjcb	D\cbY
5XUa ' <i 'vyfh<="" td=""><td>Ü</td><td>8if]b['Wcbgi`HUH]cb \cifg'cf'Vm Uddc]bhaYbh</td><td>%\$, FcVYfh KYVghYf</td><td>-',)`%%)</td></i>	Ü	8if]b['Wcbgi`HUH]cb \cifg'cf'Vm Uddc]bhaYbh	%\$, FcVYfh KYVghYf	-',)`%%)

'Hi hcfg'

B Ua Y	9a U]`	5j U]`UV]`] m	@cWUh]cb	D\cbY
< YUh\Yf`7 cbhUbh	\"WcbhJbh4 i bgk "YXi "Ui	Hi hcf]U`	%(\$"FcVYfh KYVghYf	B#5
Hca 'D\]``]dgcb	g"d\]``]dgcb4 i bgk "YXi "Ui		%(\$'FcVYfh KYVghYf	B#5
< Ua]g\ '8]I cb	\Ua]g\"X]l cb4 i bgk "YXi "Ui	Hi hcf]U`	%(\$'FcVYfh KYVghYf	B <i>#</i> 5

GWXcc`7cbHJWh =bZcfa Uh]cb

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

D\cbY. f\$&Ł'-',) '(,) *

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'thY'HfUX]tjcbU``7i gtcX]Ubgž thY'6YXY[U'`fPYbg]b[tcb'WJadi gtž; UX][U'`fP]tmUbX'5fth' '8Yg][b'7Uadi gYgt'UbX'thY'B[i bbUkU' dYcd'Y'fbi gtfU']Ub'8YZYbW': cfW'5WJXYam']b'7UbVYffUt'cZthY'`UbXg'k\YfY'YUWX'WJadi g'cZl BGK ']g`cWJtYX''$

7ci fgY 8YW]`g

7 fYX]h'Dc]bhg'*

Gi a a UfmcZh\Y 7ci fgY

Gi VYWh5fYU. ? ge[U

 $\label{thm:continuity:limit} $$H\g''Wci\ fgY'dfcj\]XYg'Ub']bhfcXi\ Whjcb'hc'gci\ bX'hYW\bc`c[\ mUbX']hg'WfYUhjj\ Y'Udd`]WUhjcbg'''Mci\ 'k\]``Yj\ U`i\ UhY'' $$$

5ggYgga Ybh

5ggYgga Ybh'HUg_g'

5ggYgga Ybh'hUg_	K Y][\h	8iY'8UHY	Gh XYbh@YUfb]b[Ci hWca Ygʻ5ggYggYX
FYa]I ·	' \$ı	% #%\$#&\$% `\$).\$\$`DA	%ž&
F YgYUfVX 'dUdYf'	&) ı	\$%#%#&\$%-`\$).\$\$`DA	ı
7 fYUhjj Y'Gci bX'Dfc YWi	()।	&&#%#&\$% `\$).\$\$`DA</td><td>%ž&Ž</td></tr></tbody></table>	

5ggYgga Ybh'8YhJ]`g

5ggYgga Ybh'% F Ya]l

GhUfh XUhY.

@Yb[h\. &!(a]bg

8YHJ]`g. '&! ('a]bg"'K f]HYb'ZYYXVUW_'ZFca ']bglfi Wfcf"

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

GYY'a ccX`Y'Zcf'XYhJ]`g"

5ggYgga Ybh& FYgYUfW dUdYf

GHJfh:XUhY.

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

8 YHJ]`g. '%) \$\$ 'k cfXg" : YYXVUW_j j]U '@A G"

 $5XX]h]cbU^XYhU]g.$

GYY'a ccX`Y'Zcf'XYhJ]`g"

5ggYgga Ybh' . '7fYUh]j Y'Gci bX'Dfc YWh

GhUfh XUhY.

@Yb[h . ``Yb[h `cZgi dd`]YX`Ub]a Uh]cb

8YHJ]`g. '%' 'a]bg"`GY`ZUggYgga YbhUbX`k f]HYb`ZYYXVUW_`dfcj]XYX"

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

GYY'a ccX`Y'Zcf'XYhJ]`g"

5 hm/b XUb WY F Yei]fYa Ybhg

7ci fgY'GWXYXi `Y

<u>J]Yk 'WUgg'hja YHUV'Y</u>

H]a YtUV`Y

8 UhY	HmdY	7 cbhYbh
	Hcd]W	K Y`Wca Y'hc'7fYUh]j Y'Gci bX'HYW\bc`c[]Yg°'
&\$`GYdhYa VYf		H\Y``YWinfY`WcbhYbhZcf`h\]g`WcifgY`]g`cb`]bY"`H\]g`]g U`ZYI]V`Y`kUmcZ`YUfb]b[žUbX`g\ci`X`U``ck`Zcf`U acfY`YId`cfUhcfmUddfcUW\`hc`h\Y`aUhYf]U`"`D`YUgY `c[`]b`hc`AccX`Y`k\YfY`h\YfY`]g`]bhfcXiWf]cb`hc`h\Y WcifgY"
		H\Y`GcibX`CV^YWh`UbX`h\Y`GcibXgWUdY
		H\Y`cb`]bY`UWNjj]hjYg`Zcf`kYY_`%k]``\Y`d`ig`hc`h\]b_ UVcihh\Y`kcfX`cZgcibX`UfcibX`igžUbX`YId`cfY `]ghYb]b[`Ug`h\Y`ZcibXUhjcb`Zcf`WfYUhjjY`aig]WU`

H\Y`cb`]bY`UWfi]fi %0 %0 %0

	aig]Wh\UhWUb`[c`cb`Zcf`mYUfg"
	±oʻth.Yʻti tocf]U`imci fi`Yl d`cfYʻth.YgYʻ]XYUgʻi g]b[ʻtocʻg gi W.`Ugʻt]a YʻgtfYthW.]b[žY`Ugt]WUi X]cžfYj YfVYfUt]cb UbXʻ[fUbi`Ufʻgmbth.Yg]g"
	Gmbh\Yg]gʻUbXʻ5`[cf]h\a g
	H\]g`k YY_`k Y`YI d`cfY`a cXY`g`cZgci bX`UbX UWci gh]Wg`h\Uh`YX`hc`gmbh\Yg]gž'UbX`Wcbg]XYf`gca Y cZh\Y`k Umg`gmbh\Yg]gYfg`\Uj Y`VYYb`i gYX`]b Wca dcg]h]cb"
	+b 'h\Y'hi hcf]U'ž'k Yfi 'ghUfh'UXX]b['j Uf]ci g'hmdYg'cZ gmbh\Yg]g'hc'ci f'UddfcUW\Yg'hc'Wca dcg]h]cb"'Mci fi U'gc'`YUfb'\ck 'hc'i gY'A +8 =]b'Dfc'Hcc'g"
[Hcd]W	H\Y'5fhcZA]I]b[
	±bʻdfYdUfUhjcbʻZcfʻh\YʻfYa]ıʻUgg][baYbhžkYfi`[c XYYdYfʻ]bhcʻh\YʻYId`cfUhjcbʻcZh\YʻUfna]l]b[ž YId`cf]b[ʻhYW\b]eiYgʻZcfʻVch\ʻaig]WUbXʻgcibX XYg][b"
	±oʻh\Yʻhi hcf]Uʻžmci fi`Yl d`cfYʻgca YʻZ bXUa YbhUʻgʻcZ a]l]b[ž]bWi X]b[ʻWca dfYgg]cbžYei Uʻ]gUh]cbʻUbX ci hdi hZcfa Uhg"
	A 11 11 5 17 VO
IGN XJC	A]I]b['K YY_
	H\YfY`UfY`bc`hi hcf]U`g`cf``YWhi fYg`h\]g`k YY_"`D`YUgY a U_Y`i gY`cZh\Y``UVg`hc`k cf_`cb`mci f`fYa]I "
Hcd]W	GmbWkfcb]g]b[¨Gci bX`UbX`-a U[Y
	Gca Yh\]b['dck YfZ ``\UddYbg'k \Yb'gci bX'UbX a cj]b[']a U[Y'Wca Y'hc[Yh\Yf"H\Y'k YY_'k Y'Yl d`cfY k Umg']b'k \]W\ k Y'WUb'ghUfh'hc'i bXYfghUbX'UbX'k cf_ k]h\ 'h\]g'fY`Uh]cbg\]d'h\fci [\'a i g]Wj]XYcg'UbX j]XYc'Ufh''Cj Yf'h\Y'bYl h'ZYk 'k YY_g'k Yfi'Yl d`cfY h\]g'a cfY'gdYW]Z]WU``m'h\fci [\'WUgY'ghi X]Yg'Zfca W]bYa Už'[Ua Yg'UbX'Ub]a Uh]cb"
	±b`h\Y`hi hcf]U``mci fi`Yl dYf]a Ybhk]h\`Wca V]b]b[]a U[Y`UbX`gci bX`k]h\]b`Dfc`Hcc`g"
	Hcd]W

K YY_`+.`&, `C WcVYf`!`% Bcj Ya VYf	Hcd]W	7 UgY Ghi X]Yg. 'Gci bX '8 Yg][b 'Zcf' 7]bYa U H\]g'k YY_'k Y'Yl d`cfY 'gca Y 'UddfcUW\Yg'hc 'Z]'a gWcf]b["'5hih]g'ghU[Yž'mci 'g\ci `X'\Uj Y'Yj Yfmh\]b[mci 'bYYX'hc 'ghUfhk cf_]b['cb'mci f'Z]bU`'Wca dcg]h]cb]b'h\Y'hi hcf]U`g'cj Yf'h\Y'bYl h'ZYk 'k YY_g"
K YY_', . '('Bcj Ya VYf'!', Bcj Ya VYf	Hcd]W	7 UgY'Ghi X]Yg. 'Gci bX'8Yg][b'UbX'5b]a Uh]cb b'h\Y'cb']bY'Yl d'cfUh]cbgžk Yfi'Yl d'cfY'gca Y gdYW]ZWWUgY'ghi X]Yg'cZh\Y'i gY'cZgci bX'UbX Ub]a Uh]cb" b'h\Y'hi hcf]U'gžmci 'WUb'Wcbh]bi Y'k cf_]b['cb'mci f Z]bU`'dfcYWh'5hih\]g'ghU[Y'mci 'a Um'U`gc'k Ubh hc'k cf_g\cd'UbmiX]Z]Wi'h]Yg'mci 'a Um'VY'\Uj]b['k]h\
K YY_``%%Bcj Ya VYf'! %) 'Bcj Ya VYf	Hcd]W	mci f'hi hcf" 7 UgY'Ghi X]Yg. 'Gci bX'8Yg][b'Zcf'; Ua Yg'UbX'J F 10 'h\Y'cb']bY'Yl d'cfUh]cbgž'k Yfi'Yl d'cfY'gca Y gdYW]Z]WWUgY'ghi X]Yg'cZh\Y'i gY'cZgci bX'UbX Ub]a Uh]cb" 10 'h\Y'hi hcf]U'gž'mci 'WUb'Wcbh]bi Y'hc'k cf_'cb'mci f Z]bU''dfcYWh]b'dfYdUfUh]cb'Zcf'bYl hk YY_fig gWYYb]b["
K YY_'%\$.'% 'Bcj Ya VYf'! &&'Bcj Ya VYf	GWYYb]b[GWfYYb]b[H\]g'k YY_'k Y'k fUd'i d'h\Y'Wti fgYž'UbX'gi [[Ygh gca Y'cddcfhi b]h]Yg'Zcf'Z fh\Yf'Yl d`cfUh]cb" Mci 'k]``'VY'gWfYYb]b['mci f'dfc YWfg'Xi f]b['h\Y hi hcf]U`"'H\]g']g'Ub'Yl WY'`YbhW\UbW'hc'Yb't5

FYgci fW/g

DfYgWf]VYX F Ygci fWYg

- Mci fî'bYYX'U'XYX]WJhYX'\UfX'Xf]j Y'Zcf'Ui X]c'a UhYf]U``fbchih\i a V'Xf]j YŁ"'H\]g'k]```U``ck 'mci 'hc ghcfY'U``'mci f'Z]'Yg'UbX'YI d`cfUh]cbg'Ug'mci 'dfc[fYgg'h\fci [\'h\Y'Wci fgYž'UbX'U``ck 'mci 'hc'k cf_'cb h\Y'`Uf[Yf'j]XYc'Z]'Yg'h\Uh'UfY'dUfhcZh\Y'Z]bU``Ugg][ba Ybh'
- 6f]b['mci f'ck b'\YUXd\cbYg"
- BchY'h\Uh`cUb'cZNcca :]Y`X`fYWcfXYfg`Zcf`Ugg][ba Ybhg`]g`YbWci fU[YXžVi hifYei]fYg`gi WW\ggZ\`i gY`]b`k YY_cbYžcf`Ub`cf]YbhUh]cb`Ug`Uddfcj YX`Vmh\Y`HYW\b]WU`F Ygci fW\'7 YbhfY\":]Y`X fYWcfXYfg`UbX`gmbh\Yg]nYfg`WUb`VY`Vcc_YX`h\fci [\`h\Y`HF 7 k YVg]hY. \hdg.##fWUfhg"i bgk "YXi "Ui #gY`Z\Y`d#\cc_]b[!Yei]da Ybh'

FYWca a YbXYX FYgci fWyg

Gi Va]gg]cb cZ5ggYgga YbhHUg_g Gi Va]gg]cb cZ5ggYgga YbhHUg_g Hi fb]h]b Gi Va]gg]cb

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

- i bXYfgHUbX'mci f'f][\hg'UbX'fYgdcbg]V]`]h]Yg'Ug'U'gh XYbhUhI BGK
 VY'Uk UfY'cZd`U[]Uf]ga ž'Wcdmf][\hz'I BGK 'Gh XYbh7cXY'cZ7cbXi WhUbX'5VWWdhUV`Y'I gY'cZ IBGK =7 HF Ygci fWrg Dc`]Wh

5WUXYa]W = DZcfa Uh]cb

: cf`YggYbhJU``gh XYbh`]bZcfa UhJcb`fY`UhJb['hc.

- fYei Yghg Zcf Yl hYbg]cb/
- `UhY`gi Va]gg]cbg`[i]XY`]bYg/
- fYj]Yk 'cZa Uf_g/
- I BGK '<YU`h\ 'UbX'GUZYhm'dc`]W[Yg/
- YI Ua]bUh]cb dfcWXi fYg/
- gdYWJU``Wcbg]XYfUhJcb`]b`h\Y`Yj YbhcZ]``bYgg'cf'a]gUXj Ybh fY/
- gh XYbhYei]hmUbX X]gUV]`]hm/
- UbX'ch\Yf'YggYbhJU`'UWUXYa]W]bZcfa UhJcbž'gYY