$$\widehat{A}_{HM,m} = \hbar \omega_m \left(\widehat{a}_m \widehat{a}_m + \frac{1}{2} \right) = \hbar \omega \left(\widehat{N}_m + \frac{1}{2} \right)$$

m Tpins HM nessou orno koljoznoa

KI agrowites tor spo thum

HHM, w = hwm am am = hwm Nm

SIGTADYIK'S GUTZNYON

affertentoparn SI - m Tponou HM me Srow our KoiDTu7a

(HAF Program Guorain) atom field tg := ex 12 (thum) SIn (m172)

to | 9m = | ex12 | (4to winnin) | sin (m172) | 1/2 Vnm Sem = 19 | Form Eom(s)

Dam: = 2 Vinin gen

6UXVOTUTO Rabi Tou m Tps mu

11 mm), II mm) of Vrangoresons The Hamm + Has

Eva, in ours I min Xam Troviam pregeron

Hem = + wmam am + + 225+5- + trgm (S++S-) (am + am) 30043 eran 60x10

XayyTroviani Rabi

'Agrownar rour Spour Stam & S-am, of Enoise Gairorran "napaloger, Star Endexen Evar you Tponos!

Huch thum âm âm + th SLŜ+Ŝ- + thgm (Ŝ+âm + Ŝ-âm) }

guria fever entre Xayıltaviani Jaynes- Commings

ASKHEH (Mapaleinouge De Enforture Tov Stiken 705 HM 7pinou m) Bpeilt TI Kajou of Spor ôta, ôôt, \$1\$-,\$\$,\$\$,\$\$,\$\$,\$\$,\$\$,\$\$,\$\$,\$\$ and uneneces 17, um> 4 12, um> B Yno Joyian 10 (ata), (a at), (\$,\$-), (\$,\$-), (\$,\$-), (\$,\$-at), (\$,\$-at (A) dia (1, n) = n (1, n) ata (4, n) = n (4, n) [a, at]=1 (=) aat= 1+ ata aat 11, n>= (1+ ata) (1, n)= (n+1) (1, n) aat 14, u)= (1+ ata) 14, u)= (n+1) 14, u) $S_{+}S_{-}|\uparrow,n\rangle = |\uparrow,n\rangle$ $S_{+}S_{-}|\downarrow,n\rangle = |\emptyset,m\rangle$ $\hat{S}_{-}\hat{S}_{+}|\uparrow,n\rangle=|0,n\rangle|n\rangle \hat{S}_{-}\hat{S}_{+}|\downarrow,n\rangle=|\downarrow,n\rangle$ Stat | 1, n > = Nn+1 | 0, m+1 > Stat | 1 n > = Vn+1 | 1, m+1> Sia IT n>= In 10, n-1> Sia II n>= In 11, n-1> 5 sat | 1 n>= (n+1) | 1, n+1> sat | 1 n>= (n+1) | 0, n+1> Sâ (1,4)= Vn (+,n-a) \$-â (+,4)= Vn (0, n-1) (B) < 1 n | ôt à | 1 n > = n (In| ata In) = n くかしるるサイル>= かそり (In | Qat | In) = m+1 (1 n | S+S- | 1 n >= 1 <\1n|\$\frac{1}{5} | \lambda n \rangle = \lambda \lambda n \rangle = \lambda
<pre> GUVEXI) cran ... (In | s-s+ | In) = (In | In) = 1

| (âtâ) Inn | (ata) In) = m |
|------------------|--|
| Laat > Inn = men | (a a+) 1 m) = 2+1 |
| (S+S-) = 4 | (\$+\$-) =0 |
| (\$_\$+) m =0 | (S_S+) 14 m) = 1 |
| (S+A) = 0 | $\langle \hat{S}_{+} \hat{Q}^{\dagger} \rangle_{(+N)} = 0$ |

$$\langle \hat{S}_{+} \hat{a}^{\dagger} \rangle_{|+n\rangle} = 0 \quad \langle \hat{S}_{+} \hat{a}^{\dagger} \rangle_{|+n\rangle} = 0$$

$$\langle \hat{S}_{+} \hat{a}^{\dagger} \rangle_{|+n\rangle} = 0 \quad \langle \hat{S}_{+} \hat{a}^{\dagger} \rangle_{|+n\rangle} = 0$$

$$\langle \hat{S}_{-} \hat{a}^{\dagger}_{m} \rangle_{|+n\rangle} = 0 \quad \langle \hat{S}_{-} \hat{a}^{\dagger}_{m} \rangle_{|+n\rangle} = 0$$



FIR THY KETESTOSH: (A) /4/(t) = (1(t) / L 11) + (2(t) / T, 4-1) = /A>

(at a) 1 = ((+) < 1 n + (2 (+) < 1 n - 1) at a ((1 (+) | 1 n) + (2 (+) | 1 n - 1 >)

= | (1(t)|2 < In| âtâ|In) + (x(t) (16) < In| âtâ| 1 n-1)

+ C2(t) G(t) < T n-1 | Qta | Ln > + | (2(t) |2 < 1 n-1 | Qta | 1 n-1 >

= |(4t)|2n < Jy/In) + (4(t) (2(t) (n-1) < Ju/ 74-1)

+ (2(t) (1(t) n < + n-1+1) + 1(2(t))2 (n-1) < + n-1+1-1)

 $= |c_1(t)|^2 n + |c_2(t)|^2 - |c_2(t)|^2 = |c_1(t)|^2 = |c_1(t)|^2 = |c_1(t)|^2 = |c_2(t)|^2$

(aa+) = (at) < 1 n + (a(t) < 1 n-1) aa+ (a(t) | 1 n) + (a(t) | 1 n-1)

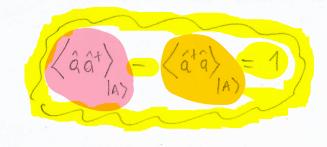
= ((1t))2 < In | aat | In) + (1(t) (1t) (1t) (1t) (1n-1)

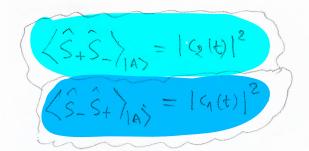
+ Q(t) (1(t) <1 n-1) aat | In) + | (2(t) |2 <1 n-1 | aat | 1 n-1 > =

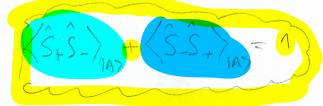
= | G(t) 12 (n+1) + G(t) G(t) n (Ly) 44-1)

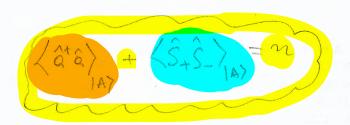
+ (2(t) (n+1) < 1 m- + / (2(t)) 2 m =

 $= |q(t)|^2 n + |q(t)|^2 + |q(t)$









$$\langle \hat{S}_{+} \hat{\alpha} \rangle_{|A\rangle} = \langle g(t) c_{1}(t) \sqrt{n} \rangle$$

$$\langle \hat{S}_{-} \hat{\alpha}^{t} \rangle_{|A\rangle} = c_{1}(t) c_{2}(t) \sqrt{n}$$

(E)
$$|\Psi_{E}(t)\rangle = C_{1}(t) |\uparrow n\rangle + C_{2}(t) |\downarrow n+1\rangle = |E\rangle$$
 Suplant answersence

(ata) = + (S+S-) (E)=

 $\begin{array}{l}
\left(\hat{S}_{+}\hat{S}_{-}\right)_{|AY|} = \left(\hat{G}_{-}(k) \left\langle + n \right| + \hat{G}_{-}(k) \left\langle + n - 1 \right| \right) \hat{S}_{+}\hat{S}_{-} \left(\hat{G}_{-}(k) \left| + n \right| + \hat{G}_{-}(k) \left| + n - 1 \right| \hat{S}_{+}\hat{S}_{-} \left| + n - 1 \right| + \hat{G}_{-}(k) \left| + n - 1 \right| + \hat{G}_{-}(k) \left| + n \right| +$

 $|c_{0}(t)|^{2} \langle \uparrow n-A| \uparrow n-A \rangle = |c_{0}(t)|^{2}$ $|c_{0}(t)|^{2} \langle \uparrow n-A| \uparrow n-A \rangle = |c_{0}(t)|^{2}$ $= |c_{0}(t)|^{2} \langle \downarrow n| + |c_{0}(t)| \langle \uparrow n-A| \rangle + |c_{0}(t)| + |c_{0}(t)|^{2} \langle \uparrow n-A| + |c_{0}(t)| + |c_{0}(t)|^{2}$ $|c_{0}(t)|^{2} \langle \uparrow n-A| + |c_{0}(t)| + |c_{0}(t)|^{2}$ $|c_{0}(t)|^{2} \langle \uparrow n-A| + |c_{0}(t)| + |c_{0}(t)|^{2}$ $|c_{0}(t)|^{2} \langle \uparrow n-A| + |c_{0}(t)| + |c_{0}(t)|^{2}$

(\$+ a) 1A) = (1/4) < 4 n | + (2/4) | 1 n-1) \$+ a (44) | 14n > + (2/4) | 1 n-1) (IB) = |C1(E)|2 (In| S+Q |In) + Cyth (1 4) S+ 6 17 4-1>+ (1t) ((t) (1n-1) sta /1n) + (e(t))2 (1n-1)5+2 (1n-1)= = |C1(+)|2 Vn (In) 1 + Cito(16) Vm-1 (14) (m-2)+ (alt)(1(6) Vn (1n-1)+ (21t) |2 \(\tau_{n-1} \langle n-2\) = (2(t) (4(t) \(\tau_n\) (S-at) = (GH) < In + GH) < T n-11) S- at (GH) In) + (21t) | T n-1) = |cn(+)|2 (1 m | S_ at | 1 m) + Cy(t) (t) (tu | S- 9+11 n-1) + Ca(+) (1+) (1 n-113-9+1+n) + 16b) 2 < 1 n-1 | 5-8+ 1 n-1 = = 19(E)12 North < 2 m/ con+1)

```
Rabi Hamilstonian
   HR = tunamam + t_12S+S_+ tgm (S++S-) (au + am) describing the interaction of a two level atom
                                                         with a single-mode harmonic field
   tgm(S+am + S_am) the so-called counter-rotating terms (agrossus)
    AJE = two din âm + to 25,5 + tog ($+ âm + $-âm)
Na stropogratosov to (âtrâm), (ŝ.ŝ.), (ŝ.am) (ŝ.am) ya zer kana ordosos
C_1(0)=1, C_2(0)=0
(E) (VE(t)) = q(t) (1, n+1) + q(t) (1, n)
                                                             C_{1}(0) = 0, C_{2}(0) = 1
  (amam) = < yalt) amam (yalt) = { c+< 1, n + 5 < 1, n - 1 | amam ( 1, n) + 5 (1, n - 1) }
           = 10,12 ( In amam I, n) + c/co ( I, n | amam 1, n-1)
          +ct ( <1, n-1 | aman 1, n) + (6) <1, n-1 | aman 1, n-1>
          = |c12 Nu Nu < 1, 11 1, 11 + c+ co Nu 1 1 1 < 1, 11 1, 11 -1>
          +com Nuva (1,n-1) 1,n) + (21° Vn-1 Vn-1 (1, n-1) 1,n-1) =
           = n. |a|2.1 + a(2(n-1).0+ aan + (n-1)|a|2.1=
          = n |c12 + n |c12 - |c12 = n (|c12 + |c2|2) - |c2|2 = n - |c2|2 =>
         = n = (G(t) 2 V
(S, S- 6 = < VA(L) | S, S- (VA(L)) = ( C < L, M) + ( 1, M-1) (S, S- (G | L, M) + (G | 1, M-1) )
          = |412 <1,4 5+3-11,4 + 9 4 <1,4 5+3-17,4-15
          + ( q < 1, n-1 | Sis | J, u> + | c| 2 < 1, n-1 | Sis | 1, n-1> =
          = |ca|2.0 + ctc2 (1, n) + n-1) + cta 0+1512 (1, n-1) =>
  SiS-> = | (e(t) | 2 V
         ( and an) + (5+5)
```

(Stam) = (4A(1) | Stam | 4A(1) >= {c\$ < 4, 11 + 5 < 7, 11 - 11 + 5 + am | C1 | 2, 11 + C6 | 1, 1 = |a|2 < 1, n | Stam | 1, n > + ata < 1, u | Stam | 1, n - 1) + + ct c (1, n-1) S, am / n) + |c|2 (1, n-1) S, am / 1, n-1)= = |9 2 Vn (4, u/1, n-1) + 9 (2. Vn-1. (4, n/34/1, n-2) + 6+ 6 Vin (1, n-1) 1, n-2) + 1512 VIN-1 (1, N-1) \$4 17, n-2) => Sign = 6(t) 4(t) · Vu (\$_ati) = < \4|t) |\$_ati| \(\pa_{A}(t) \) = { c\(\pa_{A}(t) \) + \(\frac{1}{2} \) = 1913 (1, 1) san 1, n) + 9 (1, 1) san 1, n-1)+ cota <1, n-1/5. am 1, n) + |col2/1, n-1/5. am 1, n-1> = = 1912 Nn+1 (Juls-11, n+1) + ctc Vn (Jul 1, n) + Cot (1, n-1/3, 1/n+1) Nn+1 + |G|2 (1, n-1/1, n) Nu > Sam = C1(t)C2(t) Vu

$$\begin{split} \left<\hat{S}_{+}\hat{a}_{m}\right|_{E} = \left<\Psi_{E}(t)\left|\hat{S}_{+}\hat{o}_{m}\right|\Psi_{E}(t)\right> &= \left<\hat{c}_{+}^{*}\langle\downarrow,n+1\right| + \left<\hat{c}_{+}^{*}\langle\uparrow,n\right|\hat{S}_{+}\hat{a}_{m}|\mathcal{I},n+1\rangle + \left<\hat{c}_{+}^{*}\langle\downarrow,n+1\right|\hat{S}_{+}\hat{a}_{m}|\mathcal{I},n\rangle + \\ &= \left|c_{n}\right|^{2}\langle\downarrow,n+1\right|\hat{S}_{+}\hat{a}_{m}|\mathcal{I},n+1\rangle + \left|c_{n}\right|^{2}\langle\uparrow,n\right|\hat{S}_{+}\hat{a}_{m}|\mathcal{I},n\rangle + \\ &= \left|c_{n}\right|^{2}\langle\downarrow,n+1\right|\hat{S}_{+}\hat{a}_{m}|\mathcal{I},n+1\rangle + \left|c_{n}\right|^{2}\langle\uparrow,n\right|\hat{S}_{+}\hat{a}_{m}|\mathcal{I},n\rangle + \\ &= \left|c_{n}\right|^{2}\langle\downarrow,n+1\right|\hat{S}_{+}n\rangle + \left|c_{n}\right|^{2}\langle\uparrow,n\right|\hat{S}_{+}\hat{a}_{m}|\mathcal{I},n\rangle + \left|c_{n}\right|^{2}\langle\uparrow,n\right|\hat{S}_{+}\hat{a}_{m}|\mathcal{I},n\rangle + \left|c_{n}\right|^{2}\langle\downarrow,n+1\right|\hat{S}_{+}\hat{a}_{m}|\mathcal{I},n\rangle + \left|c_{n}\right|^{2}\langle\downarrow,n+1\right|\hat{S}_{$$

 $\begin{array}{lll}
& & & \\$

 $APA \qquad \left\langle \hat{a}_{m}^{\dagger} \hat{a}_{m} \right\rangle_{\oplus} + \left\langle \hat{S}_{+} \hat{S}_{-} \right\rangle_{\oplus} = n+1 \qquad (4.64)$