(/users/salim-barzani)

Question:Why i can't get same result by same method and substitution is nonsense?

Posted: salim-barzani (/users/salim-barzani) 245 (/users/salim-barzani/reputation) **Product:** Maple (/products/Maple)

parameter (/tags/parameter) substitution (/tags/substitution) pde (/tags/pde) pdetest (/tags/pdetest) shift (/tags/shift)

3 hours ago

0

i saw in a lot paper they say samething and most of them don't talk about that which how we get phase shift parameter in here he talk how we can get but i try to figure out how he get i try a lot of trail but i didn't reach my goal can any one explain what i did mistak ?

3. The (1 + 1)-dimensional shallow water wave equation

We first study the (1 + 1)-dimensional shallow water wave equation

$$u_t + u_x - u_{xxt} - 4uu_t - 2u_x\partial_x^{-1}u_t = 0. \quad (11)$$

We first use the potential transformation

$$u(x,t) = v_x(x,t), \quad (12)$$

that will carry (11) to

$$v_{xt} + v_{xx} - v_{xxxt} - 4v_xv_{xt} - 2v_{xx}v_t = 0. \quad (13)$$

Substituting

$$v(x,t) = e^{\theta_i}, \quad \theta_i = k_ix - c_it, \quad (14)$$

into the linear terms of Eq. (13), and solving the resulting equation we obtain the dispersion relation

$$c_i = \frac{k_i}{1-k_i^2}, \quad i = 1,2,\ldots,N, \quad k_i \neq \pm 1, \quad (15)$$

and hence θ_i becomes

$$\theta_i = k_ix - \frac{k_i}{1-k_i^2}t. \quad (16)$$

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To determine R, we substitute

$$v(x,t) = R(\ln f(x,t))_x = R\frac{f_x(x,t)}{f(x,t)}, \quad (17)$$

into Eq. (13) and solve to find that $R = 2$ where the auxiliary function is given by

$$f(x,t) = 1 + e^{k_1x - \frac{k_1}{1-k_1^2}t}. \quad (18)$$

This means that the solution is given by

$$v(x,t) = \frac{2k_1e^{k_1x-\frac{k_1}{1-k_1^2}t}}{\ldots}. \quad (19)$$

$$1+e^{k_1x-\frac{k_1}{1-k_1^2}t}$$

Using (12) gives the single soliton solution of (11) by

$$u(x,t)=\frac{2k_1^2e^{k_1x-\frac{k_1}{1-k_1^2}t}}{\left(1+e^{k_1x-\frac{k_1}{1-k_1^2}t}\right)^2}. \tag{20}$$

For two-soliton solutions, we substitute

$$v(x,t)=2(\ln f(x,t))_x, \tag{21}$$

where the auxiliary function in this case is given by

$$f(x,t)=1+e^{\theta_1}+e^{\theta_2}+a_{12}e^{\theta_1+\theta_2}, \tag{22}$$

into (13), where θ_1 and θ_2 are given in (16), where we find the phase shift a_{12} is given by

$$a_{12}=\frac{(k_1-k_2)^2}{(k_1+k_2)^2}, \tag{23}$$

and hence

$$a_{ij}=\frac{(k_i-k_j)^2}{(k_i+k_j)^2},\quad 1\leqslant i<j\leqslant N. \tag{24}$$

This in turn gives

$$f(x,t)=1+e^{k_1x-\frac{k_1}{1-k_1^2}t}+e^{k_2x-\frac{k_2}{1-k_2^2}t}+\frac{(k_1-k_2)^2}{(k_1+k_2)^2}e^{(k_1+k_2)x-\left(\frac{k_1}{1-k_1^2}+\frac{k_2}{1-k_2^2}\right)t}. \tag{25}$$

It is interesting to note that the (1 + 1)-dimensional shallow water wave Eq. (11) does not show resonance because $a_{12}\neq 0$ or ∞ for $|k_1|\neq|k_2|$.

To determine the two-soliton solutions explicitly, we substitute (25) into the formula $u(x,t)=2(\ln f(x,t))_{xx}$.

Similarly, to determine the three-soliton solutions, we set

$$f(x,t)=1+\exp(\theta_1)+\exp(\theta_2)+\exp(\theta_3)+a_{12}\exp(\theta_1+\theta_2)+a_{23}\exp(\theta_2+\theta_3)+a_{13}\exp(\theta_1+\theta_3)+b_{123}\exp(\theta_1+\theta_2+\theta_3), \tag{26}$$

into (21) and substitute it into (13) to find that

$$b_{123}=a_{12}a_{13}a_{23}. \tag{27}$$

To determine the three-soliton solutions explicitly, we substitute the last result for $f(x,t)$ in the formula $u(x,t)=2(\ln f(x,t))_{xx}$. The higher level soliton solutions, for $n\geqslant 4$ can be obtained in a parallel manner. This confirms that

```
> restart
> with(PDEtools) :
> with(LinearAlgebra) :
> #with(Physics) :
> with(SolveTools) :
>  undeclare(prime)
```

There is no more prime differentiation variable; all derivatives will be displayed as indexed functi **(1)**

```
> declare(u(x, t)) :
```

u(x, t) will now be displayed as u **(2)**

```
> declare(v(x, t)) :
```

v(x, t) will now be displayed as v **(3)**

```
> declare(f(x, t))
```

f(x, t) will now be displayed as f **(4)**

```
> pde := diff(u(x, t), t) + diff(u(x, t), x) − diff(u(x, t), x$2, t) − 4·u(x, t)·diff(u(x, t), t) −2·diff(u(x, t), x) ∫diff(u(x, t), t) dx
  = 0
```

$pde := u_t + u_x - u_{t,x,x} - 4\,u\,u_t - 2\,u_x\left(\int u_t\,dx\right) = 0$ **(5)**

```
> K := u(x, t) = diff(v(x, t), x)
```

$K := u = v_x$ **(6)**

```
> pde1 := subs(K, pde)
```

$pde1 := v_{x,t} + v_{x,x} - v_{x,t,x,x} - 4\,v_x v_{x,t} - 2\,v_{x,x}\left(\int v_{x,t}\,dx\right) = 0$ **(7)**

```
> pde1 := %
```

$pde1 := v_{t,x} + v_{x,x} - v_{t,x,x,x} - 4\,v_x v_{t,x} - 2\,v_{x,x} v_t = 0$ **(8)**

```
>
> Q := v(x, t) = 2·diff((ln(f(x, t))), x)
```

$Q := v = \frac{2 f_x}{f}$ **(9)**

>

> $L := \mathit{eval}(\mathit{pde1}, Q)$

$$L := \frac{2f_{t,x,x}}{f} - \frac{4f_{t,x}f_x}{f^2} - \frac{2f_{x,x}f_t}{f^2} + \frac{4f_x^2 f_t}{f^3} + \frac{2f_{x,x,x}}{f} - \frac{6f_{x,x}f_x}{f^2} + \frac{4f_x^3}{f^3} - \frac{2f_{t,x,x,x,x}}{f} + \frac{8f_{t,x,x,x}f_x}{f^2} - \frac{24f_{t,x,x}f_x^2}{f^3} + \frac{12f_{t,x,x}f_{x,x}}{f^2} + \frac{48f_{t,x}f_x^3}{f^4} - \frac{48f_{t,x}f_xf_{x,x}}{f^3} + \frac{8f_{t,x}f_{x,x,x}}{f^2} + \frac{2f_{x,x,x,x}f_t}{f^2} - \frac{16f_{x,x,x}f_tf_x}{f^3} + \frac{72f_{x,x}f_tf_x^2}{f^4} - \frac{12f_{x,x}^2 f_t}{f^3} - \frac{48f_x^4 f_t}{f^5} - 4\left(\frac{2f_{x,x}}{f} - \frac{2f_x^2}{f^2}\right)\left(\frac{2f_{t,x,x}}{f} - \frac{4f_{t,x}f_x}{f^2} - \frac{2f_{x,x}f_t}{f^2} + \frac{4f_x^2f_t}{f^3}\right) - 2\left(\frac{2f_{x,x,x}}{f} - \frac{6f_{x,x}f_x}{f^2} + \frac{4f_x^3}{f^3}\right)\left(\frac{2f_{t,x}}{f} - \frac{2f_xf_t}{f^2}\right) = 0 \quad (10)$$

> numer(lhs(**(10)**))*denom(rhs(**(10)**)) = numer(rhs(**(10)**))*denom(lhs(**(10)**))

$$2f^2\left(f_{x,x,x}f^2 - f^2 f_{t,x,x,x,x} + f_{t,x,x}f^2 - 2f_{t,x}f_xf - 3f_{x,x}f_xf + 4ff_xf_{t,x,x,x} - f_{x,x}f_tf - 2ff_{x,x}f_{t,x,x} + ff_tf_{x,x,x,x} + 4f_{t,x}f_xf_{x,x} + 2f_x^3 + 2f_x^2f_t - 4f_{t,x,x}f_x^2 - 4f_{x,x,x}f_tf_x + 2f_{x,x}^2f_t\right) = 0 \quad (11)$$

> simplify(**(11)**)

$$2f^2\left(f_{x,x,x}f^2 - f^2 f_{t,x,x,x,x} + f_{t,x,x}f^2 - 2f_{t,x}f_xf - 3f_{x,x}f_xf + 4ff_xf_{t,x,x,x} - f_{x,x}f_tf - 2ff_{x,x}f_{t,x,x} + ff_tf_{x,x,x,x} + 4f_{t,x}f_xf_{x,x} + 2f_x^3 + 2f_x^2f_t - 4f_{t,x,x}f_x^2 - 4f_{x,x,x}f_tf_x + 2f_{x,x}^2f_t\right) = 0 \quad (12)$$

> $\dfrac{\%}{2f(x,t)^2}$

$$f_{x,x,x}f^2 - f^2 f_{t,x,x,x,x} + f_{t,x,x}f^2 - 2f_{t,x}f_xf - 3f_{x,x}f_xf + 4ff_xf_{t,x,x,x} - f_{x,x}f_tf - 2ff_{x,x}f_{t,x,x} + ff_tf_{x,x,x,x} + 4f_{t,x}f_xf_{x,x} + 2f_x^3 + 2f_x^2f_t - 4f_{t,x,x}f_x^2 - 4f_{x,x,x}f_tf_x + 2f_{x,x}^2f_t = 0 \quad (13)$$

> $F1 := \%$

$$F1 := f_{x,x,x}f^2 - f^2 f_{t,x,x,x,x} + f_{t,x,x}f^2 - 2f_{t,x}f_xf - 3f_{x,x}f_xf + 4ff_xf_{t,x,x,x} - f_{x,x}f_tf - 2ff_{x,x}f_{t,x,x} + ff_tf_{x,x,x,x} + 4f_{t,x}f_xf_{x,x} + 2f_x^3 + 2f_x^2f_t - 4f_{t,x,x}f_x^2 - 4f_{x,x,x}f_tf_x + 2f_{x,x}^2f_t = 0 \quad (14)$$

> $PP := \mathit{simplify}(F1)$

$$PP := -f^2 f_{t,x,x,x,x} + 4ff_xf_{t,x,x,x} + ff_tf_{x,x,x,x} + \left(f^2 - 2ff_{x,x} - 4f_x^2\right)f_{t,x,x} + \left(f^2 - 4f_tf_x\right)f_{x,x,x} + 2f_{x,x}^2f_t + \left(4f_{t,x}f_x - f\left(f_t + 3f_x\right)\right)f_{x,x} - 2f_{t,x}f_xf + 2f_x^2\left(f_t + f_x\right) = 0 \quad (15)$$

> $\mathit{collect}(\%, f)$

$$\left(-f_{t,x,x,x,x} + f_{t,x,x} + f_{x,x,x}\right)f^2 + \left(4f_xf_{t,x,x,x} + f_tf_{x,x,x,x} - 2f_{x,x}f_{t,x,x} + \left(-f_t - 3f_x\right)f_{x,x} - 2f_{t,x}f_x\right)f - 4f_{t,x,x}f_x^2 - 4f_{x,x,x}f_tf_x + 2f_{x,x}^2f_t + 4f_{t,x}f_xf_{x,x} + 2f_x^2\left(f_t + f_x\right) = 0 \quad (16)$$

> [redacted]

> $PPP := \%$

$$PPP := \left(-f_{t,x,x,x,x} + f_{t,x,x} + f_{x,x,x}\right)f^2 + \left(4f_xf_{t,x,x,x} + f_tf_{x,x,x,x} - 2f_{x,x}f_{t,x,x} + \left(-f_t - 3f_x\right)f_{x,x} - 2f_{t,x}f_x\right)f - 4f_{t,x,x}f_x^2 - 4f_{x,x,x}f_tf_x + 2f_{x,x}^2f_t + 4f_{t,x}f_xf_{x,x} + 2f_x^2\left(f_t + f_x\right) = 0 \quad (17)$$

> [redacted]

> LL := (−diff(diff(diff(diff(diff(f(x, t), t), x), x), x), x) + diff(diff(diff(f(x, t), t), x), x) + diff(diff(diff(f(x, t), x), x), x)) = 0

$$LL := -f_{t,x,x,x,x} + f_{t,x,x} + f_{x,x,x} = 0 \quad (18)$$

> #N-Soliton−solution

> #i will substitute in linear part first

> #N=1

> $S2 := f(x,t) = 1 + \exp(k[1]\,x - c[1]\cdot t)$

$$S2 := f = 1 + e^{-c_1 t + k_1 x} \quad (19)$$

> eq5 := normal(eval(LL, S2))

$$eq5 := c_1 k_1^4 e^{-c_1 t + k_1 x} - c_1 k_1^2 e^{-c_1 t + k_1 x} + k_1^3 e^{-c_1 t + k_1 x} = 0 \quad (20)$$

> indets(eq5);

$$\left\{t, x, c_1, k_1, e^{-c_1 t + k_1 x}\right\} \quad (21)$$

> $eq := \mathit{algsubs}\left(e^{-c_1 t + k_1 x} = V, eq5\right)$

$$eq := c_1 k_1^4 V - c_1 k_1^2 V + k_1^3 V = 0 \quad (22)$$

> indets(eq);

$$\{V, c_1, k_1\} \quad (23)$$

```
eqs := {coeffs(collect(numer(normal(lhs(eq))), {V},'distributed'), {V})}:
nops(%);
indets(eqs);
```

1

$\{c_1, k_1\}$ **(24)**

```
> vars := indets(eqs);
  ans := solve(eqs, {c_1, k_1})
```

$vars := \{c_1, k_1\}$

$ans := \{c_1 = c_1, k_1 = 0\}, \left\{c_1 = -\frac{k_1}{k_1^2 - 1}, k_1 = k_1\right\}$ **(25)**

```
> case2 := ans[2]
```

$case2 := \left\{c_1 = -\frac{k_1}{k_1^2 - 1}, k_1 = k_1\right\}$ **(26)**

```
> FF := subs(case2, S2)
```

$FF := f = 1 + e^{\frac{k_1 t}{k_1^2 - 1} + k_1 x}$ **(27)**

```
> F11 := eval(Q, FF)
```

$F11 := v = \frac{2 k_1 e^{\frac{k_1 t}{k_1^2 - 1} + k_1 x}}{1 + e^{\frac{k_1 t}{k_1^2 - 1} + k_1 x}}$ **(28)**

```
> pdetest(F11, pde1)
```

0 **(29)**

```
> Fe := eval(K, F11)
```

$Fe := u = \frac{2 k_1^2 e^{\frac{k_1 t}{k_1^2 - 1} + k_1 x}}{1 + e^{\frac{k_1 t}{k_1^2 - 1} + k_1 x}} - \frac{2 k_1^2 \left(e^{\frac{k_1 t}{k_1^2 - 1} + k_1 x}\right)^2}{\left(1 + e^{\frac{k_1 t}{k_1^2 - 1} + k_1 x}\right)^2}$ **(30)**

```
> pdetest(Fe, pde)
```

0 **(31)**

```
> #N=2
> S22 := v(x, t) = 1 + exp(k[1] x - c[1]·t) + exp(k[2] x - c[2]·t) + A[1] exp(k[1] x - c[1]·t + k[2] x - c[2]·t)
```

$S22 := v = 1 + e^{-c_1 t + k_1 x} + e^{-c_2 t + k_2 x} + A_1 e^{-c_1 t - c_2 t + k_1 x + k_2 x}$ **(32)**

```
> tr1 := c_1 = -k_1/(k_1^2 - 1); tr2 := c_2 = -k_2/(k_2^2 - 1)
```

$tr1 := c_1 = -\frac{k_1}{k_1^2 - 1}$

$tr2 := c_2 = -\frac{k_2}{k_2^2 - 1}$ **(33)**

```
> S3 := subs({tr1, tr2}, S22)
```

$S3 := v = 1 + e^{\frac{k_1 t}{k_1^2 - 1} + k_1 x} + e^{\frac{k_2 t}{k_2^2 - 1} + k_2 x} + A_1 e^{\frac{k_1 t}{k_1^2 - 1} + \frac{k_2 t}{k_2^2 - 1} + k_1 x + k_2 x}$ **(34)**

```
> eq1 := normal(eval(pde1, S3))
```

$eq1 :=$ **(35)**

$$-\frac{1}{\left(k_1^2 - 1\right)\left(k_2^2 - 1\right)} \left(6 e^{\frac{k_1 \left(x k_1^2 + t - x\right)}{k_1^2 - 1}} \right.$$

$$\frac{x k_1^3 k_2^2 + x k_1^2 k_2^3 + t k_1^2 k_2 + t k_1 k_2^2 - x k_1^3 - x k_1^2 k_2 - x k_1 k_2^2 - x k_2^3 - t k_1 - t k_2 + k_1 x + k_2 x}{\ldots}$$

$$e^{\frac{\cdots}{\left(k_1^2-1\right)\left(k_2^2-1\right)}} A_1 k_1^4 k_2$$

$$+ 16\, e^{\frac{k_1\left(x k_1^2+t-x\right)}{k_1^2-1}} e^{\frac{x k_1^3 k_2^2 + x k_1^2 k_2^3 + t k_1^2 k_2 + t k_1 k_2^2 - x k_1^3 - x k_1^2 k_2 - x k_1 k_2^2 - x k_2^3 - t k_1 - t k_2 + k_1 x + k_2 x}{\left(k_1^2-1\right)\left(k_2^2-1\right)}} A_1 k_1^3 k_2^2$$

$$+ 12\, e^{\frac{k_1\left(x k_1^2+t-x\right)}{k_1^2-1}} e^{\frac{x k_1^3 k_2^2 + x k_1^2 k_2^3 + t k_1^2 k_2 + t k_1 k_2^2 - x k_1^3 - x k_1^2 k_2 - x k_1 k_2^2 - x k_2^3 - t k_1 - t k_2 + k_1 x + k_2 x}{\left(k_1^2-1\right)\left(k_2^2-1\right)}} A_1 k_1^2 k_2^3$$

$$+ 2\, e^{\frac{k_1\left(x k_1^2+t-x\right)}{k_1^2-1}} e^{\frac{x k_1^3 k_2^2 + x k_1^2 k_2^3 + t k_1^2 k_2 + t k_1 k_2^2 - x k_1^3 - x k_1^2 k_2 - x k_1 k_2^2 - x k_2^3 - t k_1 - t k_2 + k_1 x + k_2 x}{\left(k_1^2-1\right)\left(k_2^2-1\right)}} A_1 k_1 k_2^4$$

$$+ 2\, e^{\frac{k_2\left(x k_2^2+t-x\right)}{k_2^2-1}} e^{\frac{x k_1^3 k_2^2 + x k_1^2 k_2^3 + t k_1^2 k_2 + t k_1 k_2^2 - x k_1^3 - x k_1^2 k_2 - x k_1 k_2^2 - x k_2^3 - t k_1 - t k_2 + k_1 x + k_2 x}{\left(k_1^2-1\right)\left(k_2^2-1\right)}} A_1 k_1^4 k_2$$

$$+ 12\, e^{\frac{k_2\left(x k_2^2+t-x\right)}{k_2^2-1}} e^{\frac{x k_1^3 k_2^2 + x k_1^2 k_2^3 + t k_1^2 k_2 + t k_1 k_2^2 - x k_1^3 - x k_1^2 k_2 - x k_1 k_2^2 - x k_2^3 - t k_1 - t k_2 + k_1 x + k_2 x}{\left(k_1^2-1\right)\left(k_2^2-1\right)}} A_1 k_1^3 k_2^2$$

$$+ 6 \left(e^{\frac{x k_1^3 k_2^2 + x k_1^2 k_2^3 + t k_1^2 k_2 + t k_1 k_2^2 - x k_1^3 - x k_1^2 k_2 - x k_1 k_2^2 - x k_2^3 - t k_1 - t k_2 + k_1 x + k_2 x}{\left(k_1^2-1\right)\left(k_2^2-1\right)}}\right)^2 A_1^2 k_1^4 k_2$$

$$+ 18 \left(e^{\frac{x k_1^3 k_2^2 + x k_1^2 k_2^3 + t k_1^2 k_2 + t k_1 k_2^2 - x k_1^3 - x k_1^2 k_2 - x k_1 k_2^2 - x k_2^3 - t k_1 - t k_2 + k_1 x + k_2 x}{\left(k_1^2-1\right)\left(k_2^2-1\right)}}\right)^2 A_1^2 k_1^3 k_2^2$$

$$+ 18 \left(e^{\frac{x k_1^3 k_2^2 + x k_1^2 k_2^3 + t k_1^2 k_2 + t k_1 k_2^2 - x k_1^3 - x k_1^2 k_2 - x k_1 k_2^2 - x k_2^3 - t k_1 - t k_2 + k_1 x + k_2 x}{\left(k_1^2-1\right)\left(k_2^2-1\right)}}\right)^2 A_1^2 k_1^2 k_2^3$$

$$+ 6 \left(e^{\frac{x k_1^3 k_2^2 + x k_1^2 k_2^3 + t k_1^2 k_2 + t k_1 k_2^2 - x k_1^3 - x k_1^2 k_2 - x k_1 k_2^2 - x k_2^3 - t k_1 - t k_2 + k_1 x + k_2 x}{\left(k_1^2-1\right)\left(k_2^2-1\right)}}\right)^2 A_1^2 k_1 k_2^4$$

$$+ e^{\frac{x k_1^3 k_2^2 + x k_1^2 k_2^3 + t k_1^2 k_2 + t k_1 k_2^2 - x k_1^3 - x k_1^2 k_2 - x k_1 k_2^2 - x k_2^3 - t k_1 - t k_2 + k_1 x + k_2 x}{\left(k_1^2-1\right)\left(k_2^2-1\right)}} A_1 k_1^5 k_2$$

$$+ 3\, e^{\frac{x k_1^3 k_2^2 + x k_1^2 k_2^3 + t k_1^2 k_2 + t k_1 k_2^2 - x k_1^3 - x k_1^2 k_2 - x k_1 k_2^2 - x k_2^3 - t k_1 - t k_2 + k_1 x + k_2 x}{\left(k_1^2-1\right)\left(k_2^2-1\right)}} A_1 k_1^4 k_2^2$$

$$+ 4\, e^{\frac{x k_1^3 k_2^2 + x k_1^2 k_2^3 + t k_1^2 k_2 + t k_1 k_2^2 - x k_1^3 - x k_1^2 k_2 - x k_1 k_2^2 - x k_2^3 - t k_1 - t k_2 + k_1 x + k_2 x}{\left(k_1^2-1\right)\left(k_2^2-1\right)}} A_1 k_1^3 k_2^3$$

$$+ 3\, e^{\frac{x k_1^3 k_2^2 + x k_1^2 k_2^3 + t k_1^2 k_2 + t k_1 k_2^2 - x k_1^3 - x k_1^2 k_2 - x k_1 k_2^2 - x k_2^3 - t k_1 - t k_2 + k_1 x + k_2 x}{\left(k_1^2-1\right)\left(k_2^2-1\right)}} A_1 k_1^2 k_2^4$$

$$+ e^{\frac{x k_1^3 k_2^2 + x k_1^2 k_2^3 + t k_1^2 k_2 + t k_1 k_2^2 - x k_1^3 - x k_1^2 k_2 - x k_1 k_2^2 - x k_2^3 - t k_1 - t k_2 + k_1 x + k_2 x}{\left(k_1^2-1\right)\left(k_2^2-1\right)}} A_1 k_1 k_2^5$$

$$+ 2\, e^{\frac{k_1\left(x k_1^2+t-x\right)}{k_1^2-1}} e^{\frac{k_2\left(x k_2^2+t-x\right)}{k_2^2-1}} k_1^4 k_2 + 4\, e^{\frac{k_1\left(x k_1^2+t-x\right)}{k_1^2-1}} e^{\frac{k_2\left(x k_2^2+t-x\right)}{k_2^2-1}} k_1^3 k_2^2$$

$$+ 4\, e^{\frac{k_1\left(x k_1^2+t-x\right)}{k_1^2-1}} e^{\frac{k_2\left(x k_2^2+t-x\right)}{k_2^2-1}} k_1^2 k_2^3 + 2\, e^{\frac{k_1\left(x k_1^2+t-x\right)}{k_1^2-1}} e^{\frac{k_2\left(x k_2^2+t-x\right)}{k_2^2-1}} k_1 k_2^4$$

$$- 18 \left(e^{\frac{x k_1^3 k_2^2 + x k_1^2 k_2^3 + t k_1^2 k_2 + t k_1 k_2^2 - x k_1^3 - x k_1^2 k_2 - x k_1 k_2^2 - x k_2^3 - t k_1 - t k_2 + k_1 x + k_2 x}{\left(k_1^2-1\right)\left(k_2^2-1\right)}}\right)^2 A_1^2 k_1^2 k_2$$

$$- 18 \left(e^{\frac{x k_1^3 k_2^2 + x k_1^2 k_2^3 + t k_1^2 k_2 + t k_1 k_2^2 - x k_1^3 - x k_1^2 k_2 - x k_1 k_2^2 - x k_2^3 - t k_1 - t k_2 + k_1 x + k_2 x}{\left(k_1^2-1\right)\left(k_2^2-1\right)}}\right)^2 A_1^2 k_1 k_2^2$$

$$- 12\, e^{\frac{k_1 (x k_1^2 + t - x)}{k_1^2 - 1}}\, e^{\frac{x k_1^3 k_2^2 + x k_1^2 k_2^3 + t k_1^2 k_2 + t k_1 k_2^2 - x k_1^3 - x k_1^2 k_2 - x k_1 k_2^2 - x k_2^3 - t k_1 - t k_2 + k_1 x + k_2 x}{(k_1^2-1)(k_2^2-1)}}\, A_1 k_1^3$$

$$- 12\, e^{\frac{k_2 (x k_2^2 + t - x)}{k_2^2 - 1}}\, e^{\frac{x k_1^3 k_2^2 + x k_1^2 k_2^3 + t k_1^2 k_2 + t k_1 k_2^2 - x k_1^3 - x k_1^2 k_2 - x k_1 k_2^2 - x k_2^3 - t k_1 - t k_2 + k_1 x + k_2 x}{(k_1^2-1)(k_2^2-1)}}\, A_1 k_2^3$$

$$- 3\, e^{\frac{x k_1^3 k_2^2 + x k_1^2 k_2^3 + t k_1^2 k_2 + t k_1 k_2^2 - x k_1^3 - x k_1^2 k_2 - x k_1 k_2^2 - x k_2^3 - t k_1 - t k_2 + k_1 x + k_2 x}{(k_1^2-1)(k_2^2-1)}}\, A_1 k_1^3 k_2$$

$$- 6\, e^{\frac{x k_1^3 k_2^2 + x k_1^2 k_2^3 + t k_1^2 k_2 + t k_1 k_2^2 - x k_1^3 - x k_1^2 k_2 - x k_1 k_2^2 - x k_2^3 - t k_1 - t k_2 + k_1 x + k_2 x}{(k_1^2-1)(k_2^2-1)}}\, A_1 k_1^2 k_2^2$$

$$- 3\, e^{\frac{x k_1^3 k_2^2 + x k_1^2 k_2^3 + t k_1^2 k_2 + t k_1 k_2^2 - x k_1^3 - x k_1^2 k_2 - x k_1 k_2^2 - x k_2^3 - t k_1 - t k_2 + k_1 x + k_2 x}{(k_1^2-1)(k_2^2-1)}}\, A_1 k_1 k_2^3$$

$$- 6\, e^{\frac{k_1 (x k_1^2 + t - x)}{k_1^2 - 1}}\, e^{\frac{k_2 (x k_2^2 + t - x)}{k_2^2 - 1}}\, k_1^2 k_2 - 6\, e^{\frac{k_1 (x k_1^2 + t - x)}{k_1^2 - 1}}\, e^{\frac{k_2 (x k_2^2 + t - x)}{k_2^2 - 1}}\, k_1 k_2^2 - 6 \left(e^{\frac{k_1 (x k_1^2 + t - x)}{k_1^2 - 1}} \right)^2 k_1^3$$

$$- 6 \left(e^{\frac{k_2 (x k_2^2 + t - x)}{k_2^2 - 1}} \right)^2 k_2^3$$

$$+ 16\, e^{\frac{k_2 (x k_2^2 + t - x)}{k_2^2 - 1}}\, e^{\frac{x k_1^3 k_2^2 + x k_1^2 k_2^3 + t k_1^2 k_2 + t k_1 k_2^2 - x k_1^3 - x k_1^2 k_2 - x k_1 k_2^2 - x k_2^3 - t k_1 - t k_2 + k_1 x + k_2 x}{(k_1^2-1)(k_2^2-1)}}\, A_1 k_1^2 k_2^3$$

$$+ 6\, e^{\frac{k_2 (x k_2^2 + t - x)}{k_2^2 - 1}}\, e^{\frac{x k_1^3 k_2^2 + x k_1^2 k_2^3 + t k_1^2 k_2 + t k_1 k_2^2 - x k_1^3 - x k_1^2 k_2 - x k_1 k_2^2 - x k_2^3 - t k_1 - t k_2 + k_1 x + k_2 x}{(k_1^2-1)(k_2^2-1)}}\, A_1 k_1 k_2^4$$

$$- 18\, e^{\frac{k_1 (x k_1^2 + t - x)}{k_1^2 - 1}}\, e^{\frac{x k_1^3 k_2^2 + x k_1^2 k_2^3 + t k_1^2 k_2 + t k_1 k_2^2 - x k_1^3 - x k_1^2 k_2 - x k_1 k_2^2 - x k_2^3 - t k_1 - t k_2 + k_1 x + k_2 x}{(k_1^2-1)(k_2^2-1)}}\, A_1 k_1^2 k_2$$

$$- 6\, e^{\frac{k_1 (x k_1^2 + t - x)}{k_1^2 - 1}}\, e^{\frac{x k_1^3 k_2^2 + x k_1^2 k_2^3 + t k_1^2 k_2 + t k_1 k_2^2 - x k_1^3 - x k_1^2 k_2 - x k_1 k_2^2 - x k_2^3 - t k_1 - t k_2 + k_1 x + k_2 x}{(k_1^2-1)(k_2^2-1)}}\, A_1 k_1 k_2^2$$

$$- 6\, e^{\frac{k_2 (x k_2^2 + t - x)}{k_2^2 - 1}}\, e^{\frac{x k_1^3 k_2^2 + x k_1^2 k_2^3 + t k_1^2 k_2 + t k_1 k_2^2 - x k_1^3 - x k_1^2 k_2 - x k_1 k_2^2 - x k_2^3 - t k_1 - t k_2 + k_1 x + k_2 x}{(k_1^2-1)(k_2^2-1)}}\, A_1 k_1^2 k_2$$

$$- 18\, e^{\frac{k_2 (x k_2^2 + t - x)}{k_2^2 - 1}}\, e^{\frac{x k_1^3 k_2^2 + x k_1^2 k_2^3 + t k_1^2 k_2 + t k_1 k_2^2 - x k_1^3 - x k_1^2 k_2 - x k_1 k_2^2 - x k_2^3 - t k_1 - t k_2 + k_1 x + k_2 x}{(k_1^2-1)(k_2^2-1)}}\, A_1 k_1 k_2^2$$

$$+ 6 \left(e^{\frac{k_1 (x k_1^2 + t - x)}{k_1^2 - 1}} \right)^2 k_1^3 k_2^2 + 6 \left(e^{\frac{k_2 (x k_2^2 + t - x)}{k_2^2 - 1}} \right)^2 k_1^2 k_2^3$$

$$- 6 \left(e^{\frac{x k_1^3 k_2^2 + x k_1^2 k_2^3 + t k_1^2 k_2 + t k_1 k_2^2 - x k_1^3 - x k_1^2 k_2 - x k_1 k_2^2 - x k_2^3 - t k_1 - t k_2 + k_1 x + k_2 x}{(k_1^2-1)(k_2^2-1)}} \right)^2 A_1^2 k_1^3$$

$$- 6 \left(e^{\frac{x k_1^3 k_2^2 + x k_1^2 k_2^3 + t k_1^2 k_2 + t k_1 k_2^2 - x k_1^3 - x k_1^2 k_2 - x k_1 k_2^2 - x k_2^3 - t k_1 - t k_2 + k_1 x + k_2 x}{(k_1^2-1)(k_2^2-1)}} \right)^2 A_1^2 k_2^3 \Bigg) = 0$$

> *indets*(*eq1*);

$$\left\{ t, x, A_1, k_1, k_2, e^{\frac{k_1 (x k_1^2 + t - x)}{k_1^2 - 1}}, e^{\frac{k_2 (x k_2^2 + t - x)}{k_2^2 - 1}}, e^{\frac{x k_1^3 k_2^2 + x k_1^2 k_2^3 + t k_1^2 k_2 + t k_1 k_2^2 - x k_1^3 - x k_1^2 k_2 - x k_1 k_2^2 - x k_2^3 - t k_1 - t k_2 + k_1 x + k_2 x}{(k_1^2-1)(k_2^2-1)}} \right\} \qquad \textbf{(36)}$$

$$\Big(\; x k_1^3 k_2^2 + x k_1^2 k_2^3 + t k_1^2 k_2 + t k_1 k_2^2 - x k_1^3 - x k_1^2 k_2 - x k_1 k_2^2 - x k_2^3 - t k_1 - t k_2 + k_1 x + k_2 x \qquad \Big)$$

> $eq3 := algsubs\left(\mathrm{e}^{\frac{\ldots}{\left(k_1^2-1\right)\left(k_2^2-1\right)}} = X, eq1\right)$

$$eq3 := -\frac{1}{\left(k_1^2-1\right)\left(k_2^2-1\right)}\Bigg(2\,\mathrm{e}^{\frac{k_1\left(x k_1^2+t-x\right)}{k_1^2-1}}\,\mathrm{e}^{\frac{k_2\left(x k_2^2+t-x\right)}{k_2^2-1}}\,k_1^4 k_2 + 4\,\mathrm{e}^{\frac{k_1\left(x k_1^2+t-x\right)}{k_1^2-1}}\,\mathrm{e}^{\frac{k_2\left(x k_2^2+t-x\right)}{k_2^2-1}}\,k_1^3 k_2^2 \tag{37}$$

$$+ 4\,\mathrm{e}^{\frac{k_1\left(x k_1^2+t-x\right)}{k_1^2-1}}\,\mathrm{e}^{\frac{k_2\left(x k_2^2+t-x\right)}{k_2^2-1}}\,k_1^2 k_2^3 + 2\,\mathrm{e}^{\frac{k_1\left(x k_1^2+t-x\right)}{k_1^2-1}}\,\mathrm{e}^{\frac{k_2\left(x k_2^2+t-x\right)}{k_2^2-1}}\,k_1 k_2^4$$

$$- 6\,\mathrm{e}^{\frac{k_1\left(x k_1^2+t-x\right)}{k_1^2-1}}\,\mathrm{e}^{\frac{k_2\left(x k_2^2+t-x\right)}{k_2^2-1}}\,k_1^2 k_2 - 6\,\mathrm{e}^{\frac{k_1\left(x k_1^2+t-x\right)}{k_1^2-1}}\,\mathrm{e}^{\frac{k_2\left(x k_2^2+t-x\right)}{k_2^2-1}}\,k_1 k_2^2 - 6\,\mathrm{e}^{\frac{k_2\left(x k_2^2+t-x\right)}{k_2^2-1}}\,A_1 k_1^2 k_2 X$$

$$- 18\,\mathrm{e}^{\frac{k_2\left(x k_2^2+t-x\right)}{k_2^2-1}}\,A_1 k_1 k_2^2 X + 16\,\mathrm{e}^{\frac{k_1\left(x k_1^2+t-x\right)}{k_1^2-1}}\,A_1 k_1^3 k_2^2 X + 12\,\mathrm{e}^{\frac{k_1\left(x k_1^2+t-x\right)}{k_1^2-1}}\,A_1 k_1^2 k_2^3 X$$

$$+ 2\,\mathrm{e}^{\frac{k_1\left(x k_1^2+t-x\right)}{k_1^2-1}}\,A_1 k_1 k_2^4 X + 2\,\mathrm{e}^{\frac{k_2\left(x k_2^2+t-x\right)}{k_2^2-1}}\,A_1 k_1^4 k_2 X + 12\,\mathrm{e}^{\frac{k_2\left(x k_2^2+t-x\right)}{k_2^2-1}}\,A_1 k_1^3 k_2^2 X$$

$$+ 16\,\mathrm{e}^{\frac{k_2\left(x k_2^2+t-x\right)}{k_2^2-1}}\,A_1 k_1^2 k_2^3 X + 6\,\mathrm{e}^{\frac{k_2\left(x k_2^2+t-x\right)}{k_2^2-1}}\,A_1 k_1 k_2^4 X - 18\,\mathrm{e}^{\frac{k_1\left(x k_1^2+t-x\right)}{k_1^2-1}}\,A_1 k_1^2 k_2 X$$

$$- 6\,\mathrm{e}^{\frac{k_1\left(x k_1^2+t-x\right)}{k_1^2-1}}\,A_1 k_1 k_2^2 X - 6\left(\mathrm{e}^{\frac{k_1\left(x k_1^2+t-x\right)}{k_1^2-1}}\right)^2 k_1^3 - 6\left(\mathrm{e}^{\frac{k_2\left(x k_2^2+t-x\right)}{k_2^2-1}}\right)^2 k_2^3 - 6X^2 A_1^2 k_1^3 - 6X^2 A_1^2 k_2^3$$

$$+ 6\,\mathrm{e}^{\frac{k_1\left(x k_1^2+t-x\right)}{k_1^2-1}}\,A_1 k_1^4 k_2 X + 18X^2 A_1^2 k_1^2 k_2^3 + 6X^2 A_1^2 k_1 k_2^4 - 18X^2 A_1^2 k_1^2 k_2 - 18X^2 A_1^2 k_1 k_2^2$$

$$- 12\,\mathrm{e}^{\frac{k_1\left(x k_1^2+t-x\right)}{k_1^2-1}}\,A_1 k_1^3 X - 12\,\mathrm{e}^{\frac{k_2\left(x k_2^2+t-x\right)}{k_2^2-1}}\,A_1 k_2^3 X + 3A_1 k_1^4 k_2^2 X + 4A_1 k_1^3 k_2^3 X + 3A_1 k_1^2 k_2^4 X - 3A_1 k_1^3 k_2 X$$

$$- 6A_1 k_1^2 k_2^2 X - 3A_1 k_1 k_2^3 X + 6X^2 A_1^2 k_1^4 k_2 + 18X^2 A_1^2 k_1^3 k_2^2 + 6\left(\mathrm{e}^{\frac{k_1\left(x k_1^2+t-x\right)}{k_1^2-1}}\right)^2 k_1^3 k_2^2 + 6\left(\mathrm{e}^{\frac{k_2\left(x k_2^2+t-x\right)}{k_2^2-1}}\right)^2$$

$$k_1^2 k_2^3 + A_1 k_1^5 k_2 X + A_1 k_1 k_2^5 X\Bigg) = 0$$

> $indets(eq3);$

$$\left\{X, t, x, A_1, k_1, k_2, \mathrm{e}^{\frac{k_1\left(x k_1^2+t-x\right)}{k_1^2-1}}, \mathrm{e}^{\frac{k_2\left(x k_2^2+t-x\right)}{k_2^2-1}}\right\} \tag{38}$$

> $eq4 := algsubs\left(\mathrm{e}^{\frac{k_2\left(x k_2^2+t-x\right)}{k_2^2-1}} = Y, eq3\right)$

$$eq4 := -\frac{1}{\left(k_1^2-1\right)\left(k_2^2-1\right)}\Bigg(6Y^2 k_1^2 k_2^3 + 2A_1 k_1^4 k_2 XY + 12A_1 k_1^3 k_2^2 XY + 16A_1 k_1^2 k_2^3 XY + 6A_1 k_1 k_2^4 XY - 6A_1 \tag{39}$$

$$k_1^2 k_2 XY - 18A_1 k_1 k_2^2 XY - 6Y^2 k_2^3 - 12A_1 k_2^3 XY + 16\,\mathrm{e}^{\frac{k_1\left(x k_1^2+t-x\right)}{k_1^2-1}}\,A_1 k_1^3 k_2^2 X + 12\,\mathrm{e}^{\frac{k_1\left(x k_1^2+t-x\right)}{k_1^2-1}}\,A_1 k_1^2 k_2^3 X$$

$$+ 2\,\mathrm{e}^{\frac{k_1\left(x k_1^2+t-x\right)}{k_1^2-1}}\,A_1 k_1 k_2^4 X - 18\,\mathrm{e}^{\frac{k_1\left(x k_1^2+t-x\right)}{k_1^2-1}}\,A_1 k_1^2 k_2 X - 6\,\mathrm{e}^{\frac{k_1\left(x k_1^2+t-x\right)}{k_1^2-1}}\,A_1 k_1 k_2^2 X$$

$$- 6\left(\mathrm{e}^{\frac{k_1\left(x k_1^2+t-x\right)}{k_1^2-1}}\right)^2 k_1^3 - 6X^2 A_1^2 k_1^3 - 6X^2 A_1^2 k_2^3 + 6\,\mathrm{e}^{\frac{k_1\left(x k_1^2+t-x\right)}{k_1^2-1}}\,A_1 k_1^4 k_2 X + 18X^2 A_1^2 k_1^2 k_2^3 + 6X^2 A_1^2 k_1 k_2^4 \ldots$$

$$- 18 X^2 A_1^2 k_1^2 k_2 - 18 X^2 A_1^2 k_1 k_2^2 - 12\, \mathrm{e}^{\frac{k_1 \left(x k_1^2 + t - x\right)}{k_1^2 - 1}} A_1 k_1^3 X + 3 A_1 k_1^4 k_2^2 X + 4 A_1 k_1^3 k_2^3 X + 3 A_1 k_1^2 k_2^4 X - 3 A_1$$

$$k_1^3 k_2 X - 6 A_1 k_1^2 k_2^2 X - 3 A_1 k_1 k_2^3 X + 6 X^2 A_1^2 k_1^4 k_2 + 18 X^2 A_1^2 k_1^3 k_2^2 + 6 \left(\mathrm{e}^{\frac{k_1 \left(x k_1^2 + t - x\right)}{k_1^2 - 1}}\right)^2 k_1^3 k_2^2 + A_1 k_1^5 k_2 X + A_1 k_1$$

$$k_2^5 X + 2\, \mathrm{e}^{\frac{k_1 \left(x k_1^2 + t - x\right)}{k_1^2 - 1}} k_1^4 k_2 Y + 4\, \mathrm{e}^{\frac{k_1 \left(x k_1^2 + t - x\right)}{k_1^2 - 1}} k_1^3 k_2^2 Y + 4\, \mathrm{e}^{\frac{k_1 \left(x k_1^2 + t - x\right)}{k_1^2 - 1}} k_1^2 k_2^3 Y + 2\, \mathrm{e}^{\frac{k_1 \left(x k_1^2 + t - x\right)}{k_1^2 - 1}} k_1 k_2^4 Y$$

$$- 6\, \mathrm{e}^{\frac{k_1 \left(x k_1^2 + t - x\right)}{k_1^2 - 1}} k_1^2 k_2 Y - 6\, \mathrm{e}^{\frac{k_1 \left(x k_1^2 + t - x\right)}{k_1^2 - 1}} k_1 k_2^2 Y \Big) = 0$$

```
> indets(eq4);
```

$$\left\{X, Y, t, x, A_1, k_1, k_2, \mathrm{e}^{\frac{k_1 \left(x k_1^2 + t - x\right)}{k_1^2 - 1}}\right\} \quad \textbf{(40)}$$

$$> eq5 := algsubs\left(\mathrm{e}^{\frac{k_1 \left(x k_1^2 + t - x\right)}{k_1^2 - 1}} = Z, eq4\right)$$

$$eq5 := -\frac{1}{\left(k_1^2 - 1\right)\left(k_2^2 - 1\right)} \Big(6 X^2 A_1^2 k_1^4 k_2 + 18 X^2 A_1^2 k_1^3 k_2^2 + 18 X^2 A_1^2 k_1^2 k_2^3 + 6 X^2 A_1^2 k_1 k_2^4 + 2 A_1 k_1^4 k_2 X Y + 12 A_1 \quad \textbf{(41)}$$

$$k_1^3 k_2^2 X Y + 16 A_1 k_1^2 k_2^3 X Y + 6 A_1 k_1 k_2^4 X Y + 6 A_1 k_1^4 k_2 X Z + 16 A_1 k_1^3 k_2^2 X Z + 12 A_1 k_1^2 k_2^3 X Z + 2 A_1 k_1 k_2^4 X Z + A_1$$

$$k_1^5 k_2 X + 3 A_1 k_1^4 k_2^2 X + 4 A_1 k_1^3 k_2^3 X + 3 A_1 k_1^2 k_2^4 X + A_1 k_1 k_2^5 X - 6 X^2 A_1^2 k_1^3 - 18 X^2 A_1^2 k_1^2 k_2 - 18 X^2 A_1^2 k_1 k_2^2 - 6 X^2 A_1^2$$

$$k_2^3 + 6 Y^2 k_1^2 k_2^3 + 2 k_1^4 k_2 Y Z + 4 k_1^3 k_2^2 Y Z + 4 k_1^2 k_2^3 Y Z + 2 k_1 k_2^4 Y Z + 6 Z^2 k_1^3 k_2^2 - 6 A_1 k_1^2 k_2 X Y - 18 A_1 k_1 k_2^2 X Y$$

$$- 12 A_1 k_2^3 X Y - 12 A_1 k_1^3 X Z - 18 A_1 k_1^2 k_2 X Z - 6 A_1 k_1 k_2^2 X Z - 3 A_1 k_1^3 k_2 X - 6 A_1 k_1^2 k_2^2 X - 3 A_1 k_1 k_2^3 X - 6 Y^2 k_2^3$$

$$- 6 k_1^2 k_2 Y Z - 6 k_1 k_2^2 Y Z - 6 Z^2 k_1^3\Big) = 0$$

```
> indets(eq5);
```

$$\{X, Y, Z, A_1, k_1, k_2\} \quad \textbf{(42)}$$

$$> \#eq5 := simplify\left(algsubs\left(\mathrm{e}^{k_2 (t w_2 + y p_2 + x)} = Z, eq4\right)\right)$$

```
> #indets(eq5);
> eqss := {coeffs(collect(numer(normal(lhs(eq5))), {X, Y, Z},'distributed'), {X, Y, Z})} :
  nops(%);
  indets(eqss);
```

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$$\{A_1, k_1, k_2\} \quad \textbf{(43)}$$

```
> vars := indets(eqss);
  ans := solve( eqs, {A1, k1, k2})
```

$$vars := \{A_1, k_1, k_2\}$$

$$ans := \{A_1 = A_1, k_1 = 0, k_2 = k_2\}, \left\{A_1 = A_1, k_1 = \frac{-1 + \sqrt{4 c_1^2 + 1}}{2 c_1}, k_2 = k_2\right\}, \left\{A_1 = A_1, k_1 = -\frac{1 + \sqrt{4 c_1^2 + 1}}{2 c_1}, k_2 = k_2\right\} \quad \textbf{(44)}$$

```
> case2 := ans[2]
```

$$case2 := \left\{A_1 = A_1, k_1 = \frac{-1 + \sqrt{4 c_1^2 + 1}}{2 c_1}, k_2 = k_2\right\} \quad \textbf{(45)}$$

```
> FF := subs(case2, S3)
```

$$FF := v = 1 + \mathrm{e}^{\frac{\left(-1 + \sqrt{4 c_1^2 + 1}\right) t}{2 c_1 \left(\frac{\left(-1 + \sqrt{4 c_1^2 + 1}\right)^2}{4 c_1^2} - 1\right)} + \frac{\left(-1 + \sqrt{4 c_1^2 + 1}\right) x}{2 c_1}} + \mathrm{e}^{\frac{k_2 t}{k_2^2 - 1} + k_2 x} + A_1\, \mathrm{e}^{\frac{\left(-1 + \sqrt{4 c_1^2 + 1}\right) t}{2 c_1 \left(\frac{\left(-1 + \sqrt{4 c_1^2 + 1}\right)^2}{4 c_1^2} - 1\right)} + \frac{k_2 t}{k_2^2 - 1} + \frac{\left(-1 + \sqrt{4 c_1^2 + 1}\right) x}{2 c_1} + k_2 x} \quad \textbf{(46)}$$

>

> pdetest(FF, pde1)

$$\frac{1}{c_1^3\left(k_2^2-1\right)\left(-1+\sqrt{4c_1^2+1}\right)}\Bigg(6 \tag{47}$$

$$e^{\frac{2\left(-2\left(\left(t k_2^2-\frac{1}{2}t+\frac{1}{2}x\right)c_1+k_2 x\right)c_1\sqrt{4c_1^2+1}+\left(t k_2^2-2t-2x\right)c_1^2-k_2\left(x k_2^2+t-x\right)c_1-x\right)}{c_1\left(-1+\sqrt{4c_1^2+1}\right)\left(k_2-1\right)\left(k_2+1\right)}}\Bigg(\Bigg(\Bigg(\frac{1}{6}\big(\big(k_2-1\big)\big(k_2$$

$$+1\big)\left(A_1 k_2^2+2A_1+2k_2\right)c_1^4\big)+\left(-\frac{2}{3}k_2^2+\frac{1}{3}-\frac{1}{2}A_1 k_2^3\right)c_1^3+\frac{2\left(A_1 k_2^2+k_2\right)c_1^2}{3}+\left(-\frac{1}{3}-\frac{A_1 k_2}{2}\right)c_1+\frac{A_1}{6}\Bigg)$$

$$\sqrt{4c_1^2+1}+\left(A_1 k_2+\frac{4}{3}\right)\left(k_2+1\right)\left(k_2-1\right)c_1^5+\left(-\frac{1}{6}A_1 k_2^4-\frac{3}{2}A_1 k_2^2-k_2-\frac{1}{3}k_2^3+\frac{2}{3}A_1\right)c_1^4+\Bigg(\frac{1}{2}A_1 k_2^3$$

$$+A_1 k_2+\frac{2}{3}k_2^2+\frac{1}{3}\Bigg)c_1^3+\frac{\left(-2A_1 k_2^2-A_1-2k_2\right)c_1^2}{3}+\left(\frac{1}{3}+\frac{A_1 k_2}{2}\right)c_1-\frac{A_1}{6}\Bigg)$$

$$k_2$$

$$e^{\frac{\left(\left(3t k_2^2-t+2x\right)c_1^2+k_2\left(x k_2^2+t+3x\right)c_1-x k_2^2+x\right)\sqrt{4c_1^2+1}+\left((-t+2x)k_2^2+3t+2x\right)c_1^2+k_2\left(x k_2^2+t-x\right)c_1+x\left(k_2^2+1\right)}{c_1\left(-1+\sqrt{4c_1^2+1}\right)\left(k_2-1\right)\left(k_2+1\right)}}$$

$$+4c_1\Bigg(A_1\Bigg(\frac{\left(c_1^3 k_2^4+5c_1^3 k_2^2-6c_1^2 k_2^3-6c_1^3+3c_1^2 k_2+8c_1 k_2^2-6c_1-3k_2\right)\sqrt{4c_1^2+1}}{12}+\left(k_2^3-k_2\right)c_1^4$$

$$+\frac{\left(3-\frac{1}{6}k_2^4-\frac{7}{2}k_2^2\right)c_1^3}{2}+\frac{\left(\frac{1}{2}k_2+k_2^3\right)c_1^2}{2}+\left(\frac{1}{2}-\frac{2k_2^2}{3}\right)c_1+\frac{k_2}{4}\Bigg)$$

$$e^{\frac{\left(2\left(t k_2^2+x\right)c_1^2+k_2\left(x k_2^2+t+3x\right)c_1-2x k_2^2+2x\right)\sqrt{4c_1^2+1}+2\left(2x k_2^2+t\right)c_1^2+k_2\left(x k_2^2+t-x\right)c_1+2x k_2^2}{c_1\left(-1+\sqrt{4c_1^2+1}\right)\left(k_2-1\right)\left(k_2+1\right)}}$$

$$+\frac{1}{3}\Bigg(A_1 k_2\Bigg(\frac{1}{4}+\frac{\left(3c_1^3 k_2^3-3c_1^3 k_2-8c_1^2 k_2^2+c_1^2+6c_1 k_2-1\right)\sqrt{4c_1^2+1}}{4}+c_1^4\left(k_2^2-1\right)+\frac{3\left(-k_2^3-3k_2\right)c_1^3}{4}$$

$$+\left(2k_2^2+\frac{1}{4}\right)c_1^2-\frac{3c_1 k_2}{2}\Bigg)$$

$$e^{\frac{\left(\left(3 t k_2^2 - t + 2 x\right) c_1^2 + 2 k_2 \left(x k_2^2 + t + x\right) c_1 - x k_2^2 + x\right) \sqrt{4 c_1^2 + 1} + \left(\left(-t + 2 x\right) k_2^2 + 3 t + 2 x\right) c_1^2 + x \left(k_2^2 + 1\right)}{c_1 \left(-1 + \sqrt{4 c_1^2 + 1}\right) \left(k_2 - 1\right) \left(k_2 + 1\right)}}\Bigg) + \frac{1}{4} \Bigg(c_1 \Big(\big(c_1^2$$

$$+ 1\big) \sqrt{4 c_1^2 + 1} - 3 c_1^2 - 1\Big) \left(k_2 + 1\right) \big(k_2$$

$$- 1\big)\, e^{\frac{2 \left(\left(\left(t k_2^2 + x\right) c_1^2 + 2 k_2 x c_1 - x k_2^2 + x\right) \sqrt{4 c_1^2 + 1} + \left(2 x k_2^2 + t\right) c_1^2 + k_2 \left(x k_2^2 + t - x\right) c_1 + x k_2^2\right)}{c_1 \left(-1 + \sqrt{4 c_1^2 + 1}\right) \left(k_2 - 1\right) \left(k_2 + 1\right)}}\Bigg) + \Bigg(-\frac{1}{4}$$

$$+ \frac{\left(c_1^2 k_2^2 + c_1^2 - 2 c_1 k_2 + 1\right) \sqrt{4 c_1^2 + 1}}{4} + c_1^3 k_2 + \frac{\left(-k_2^2 - 3\right) c_1^2}{4} + \frac{c_1 k_2}{2} \Bigg) A_1^2 \big(c_1 k_2^2 - c_1$$

$$- k_2\big)\, e^{\frac{2 \left(\left(\left(t k_2^2 + x\right) c_1^2 + k_2 \left(x k_2^2 + t + x\right) c_1 - x k_2^2 + x\right) \sqrt{4 c_1^2 + 1} + \left(2 x k_2^2 + t\right) c_1^2 + x k_2^2\right)}{c_1 \left(-1 + \sqrt{4 c_1^2 + 1}\right) \left(k_2 - 1\right) \left(k_2 + 1\right)}}$$

$$- \frac{c_1^2 k_2^3\, e^{\frac{2 \left(2 \left(\left(t k_2^2 - \frac{1}{2} t + \frac{1}{2} x\right) c_1 + \frac{k_2 \left(x k_2^2 + t + x\right)}{2}\right) c_1 \sqrt{4 c_1^2 + 1} + \left(-t k_2^2 + 2 t + 2 x\right) c_1^2 + x\right)}{c_1 \left(-1 + \sqrt{4 c_1^2 + 1}\right) \left(k_2 - 1\right) \left(k_2 + 1\right)}} \left(-1 + \sqrt{4 c_1^2 + 1}\right)}{4} \Bigg)\Bigg)\Bigg)\Bigg)$$

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